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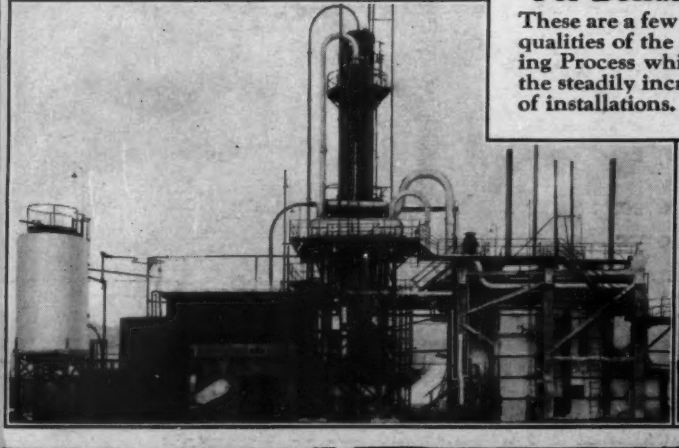

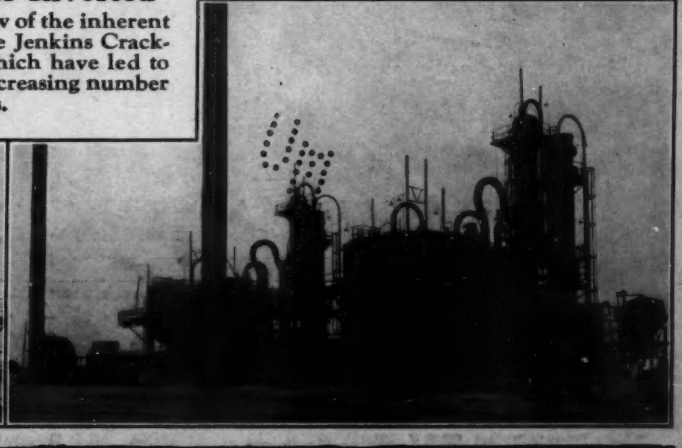

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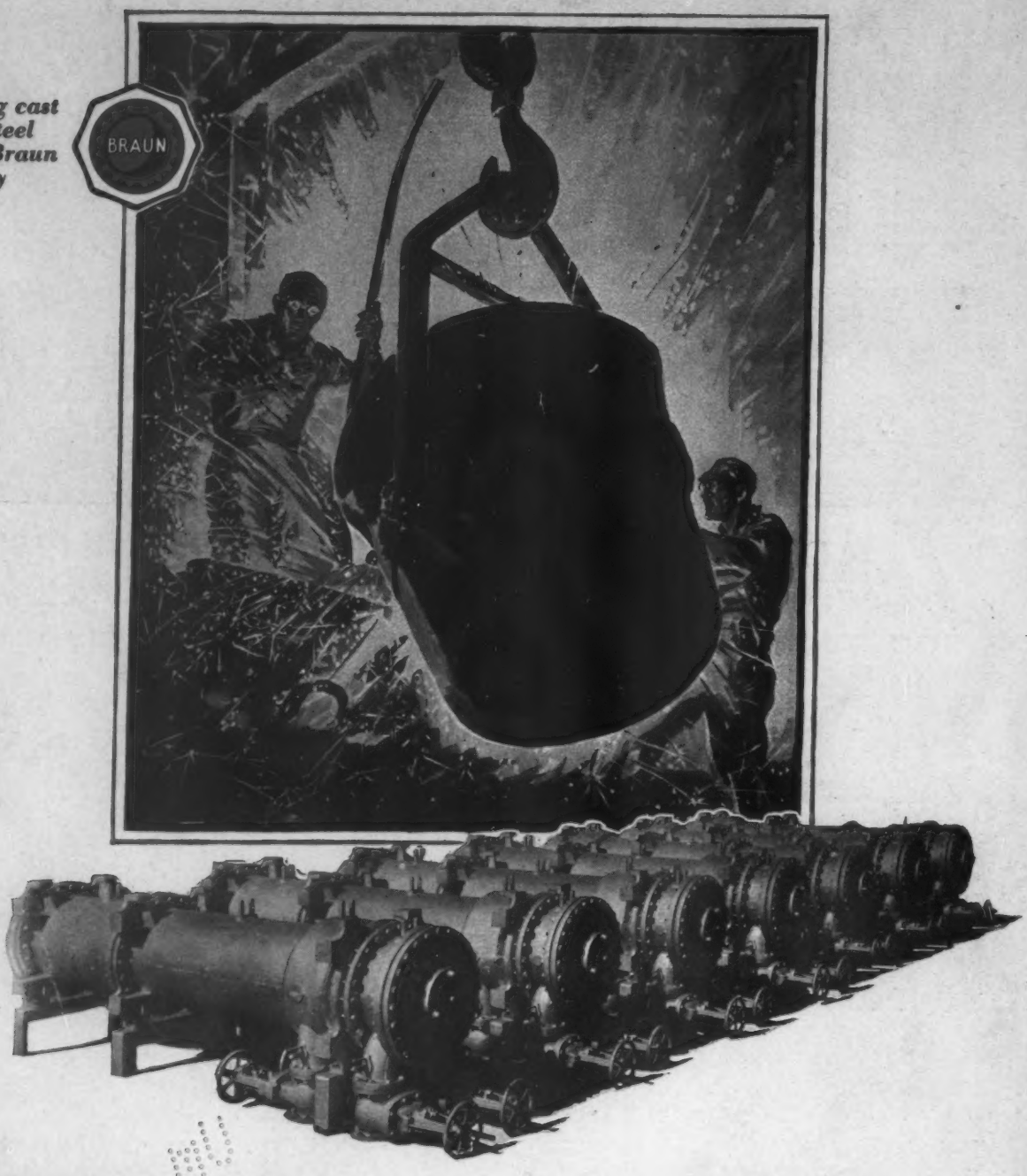

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GEORGE REID, *Associate Editor*

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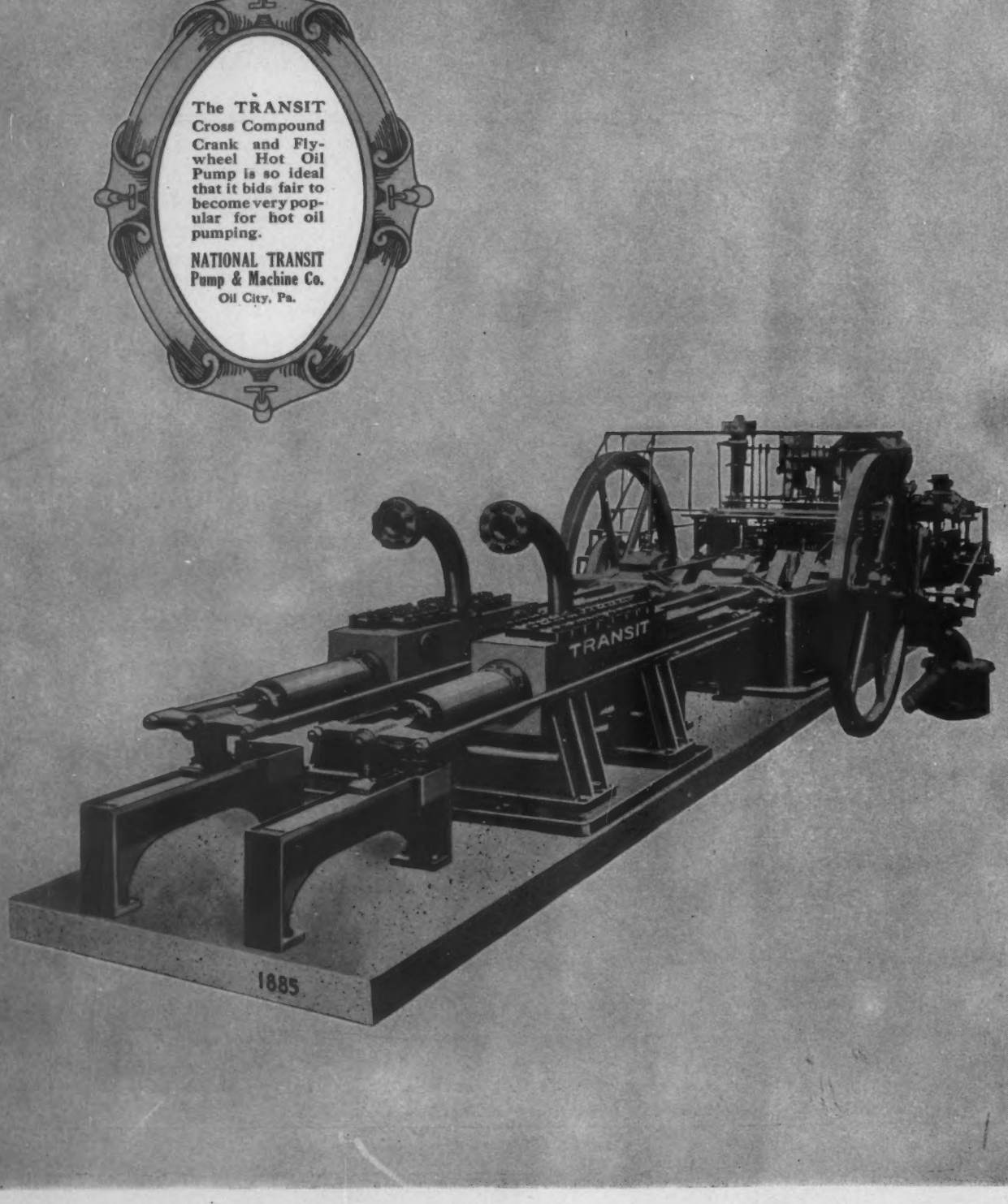

A. P. I. Division of Refining

THROUGH the realignment of American Petroleum Institute activities to embrace three major departments, officially designated as the Divisions of Production, Refining, and Marketing, a valuable opportunity is provided the refining industry to work together toward the solution of a number of problems both major and minor, which hamper the progress of the refining art. The concentration of effort toward unriddling of knotty questions may in many cases benefit but few companies, in other instances many refineries may profit, and in all such undertakings and subsequent developments the refining industry as a whole may be improved in its operating efficiency; and efficient operation of the manufacturing department, after all, is the mainspring of existence. To do much, however, it is essential that the industry drop the habit of making a fetish of secrecy. How well the industry progresses collectively is governed by willingness to contribute collectively.

The opportunity is afforded through the creation of the Division of Refining for periodic regional conferences or conventions where tentative solution of problems peculiar to a given refining district or, to the industry as a whole, may be discussed by refinery technologists, engineers, superintendents and operators. It is possible that the years work done by refinery men in the various regions throughout any given year may be the basis of highly interesting and instructive papers for presentation at group sessions at the annual meeting of the A. P. I. The success of such a program depends almost in its entirety upon the executive endorsement and the energetic and progressive executive will not only endorse the work of his refining department personnel along such lines but will instruct those engaged in manufacture that they must participate in the work of the Refining Division.

The action of the board of directors of the American Petroleum Institute instructs the special Committee on Divisional Organization and Procedure, to make any reorganization of the Institute's present committees or method of procedure necessary to make effective its plan of divisional organization.

The resolution which effects the realignment of Institute activities states that each of the three divisions shall have a general committee composed of 25 members, each of whom must be actively engaged in that particular branch of the industry. Five members of this committee shall be appointed by the president of the Institute from among members of the board of directors. The other 20 members shall be elected by the enrolled members of the particular division. Membership of this committee of 25 for the first year, however, will be appointed by the president upon recommendation of the special Committee on Divisional Organization and Procedure. They will hold office for one year, as the resolution provides that the term of office of each committeeman shall end with each calendar year. This appointed general committee for each division will be announced in the near future.

As each division general committee shall have a chairman, a vice-chairman and a secretary, and the action by the board states that "the vice-president of the American Petroleum Institute representing 'Manufacture' shall be, ex-officio, chairman of the General Committee for the Division of Refining." Thus, the chairman of the general committee for this division is W. M. Irish of The Atlantic Refining Company, Philadelphia. As the executive vice-president of the Institute shall be, ex-officio, vice-chairman for each of the three divisions, then this office for the Division of Refining is held by W. R. Boyd, Jr. The secretarial duties for each division shall be performed by that member of the salaried staff of the Institute who may from time to time be designated by the executive vice-president.

In order to have and maintain uniformity in organization and procedure for the three divisions a committee composed of E. B. Reeser, president of the Institute; W. N. Davis, vice-president for Production; W. M. Irish, vice-president for Manufacture; Henry M. Dawes, vice-president for Marketing, and W. R. Boyd, Jr., executive vice-president of the Institute, was appointed and empowered to formulate and promulgate as the act of the board the method of organization and the rules of procedure for the three divisions.

The preliminary regulations for the divisions provide that headquarters for each division shall be maintained at the general office of the Institute, and there shall be a separate divisional membership open to all interested members of the Institute upon payment of an annual fee not to exceed $5.00. Associate divisional memberships are open to individuals not engaged in the petroleum industry. The resolution provides for the appointment of regional or district or chapter committees to be constituted in accordance with the procedure prescribed. Provision is made for perfecting a program of mid-year meetings when funds are available and the expenditure authorized properly.

To those who have been earnestly seeking a forum wherein problems of refinery technology may be centered the creation of the Division of Refining is a welcome innovation, for through this plan the activities of the refinery technologists may be widened in scope and provision is made for the establishment of a continuous program of endeavor the value of which is difficult of appraisal.

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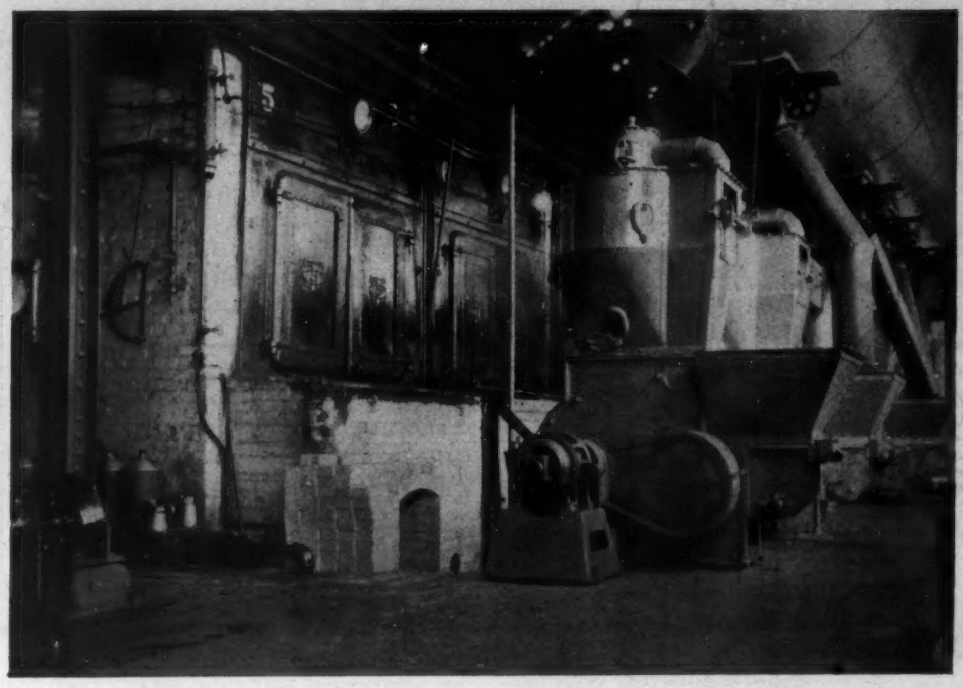


Four Coke Pulverizers used in burning Petroleum Coke under horizontal boilers

Petroleum Coke and Its Utilization

By M. E. SCHULZ
Chief Engineer, Paragon Refining Company

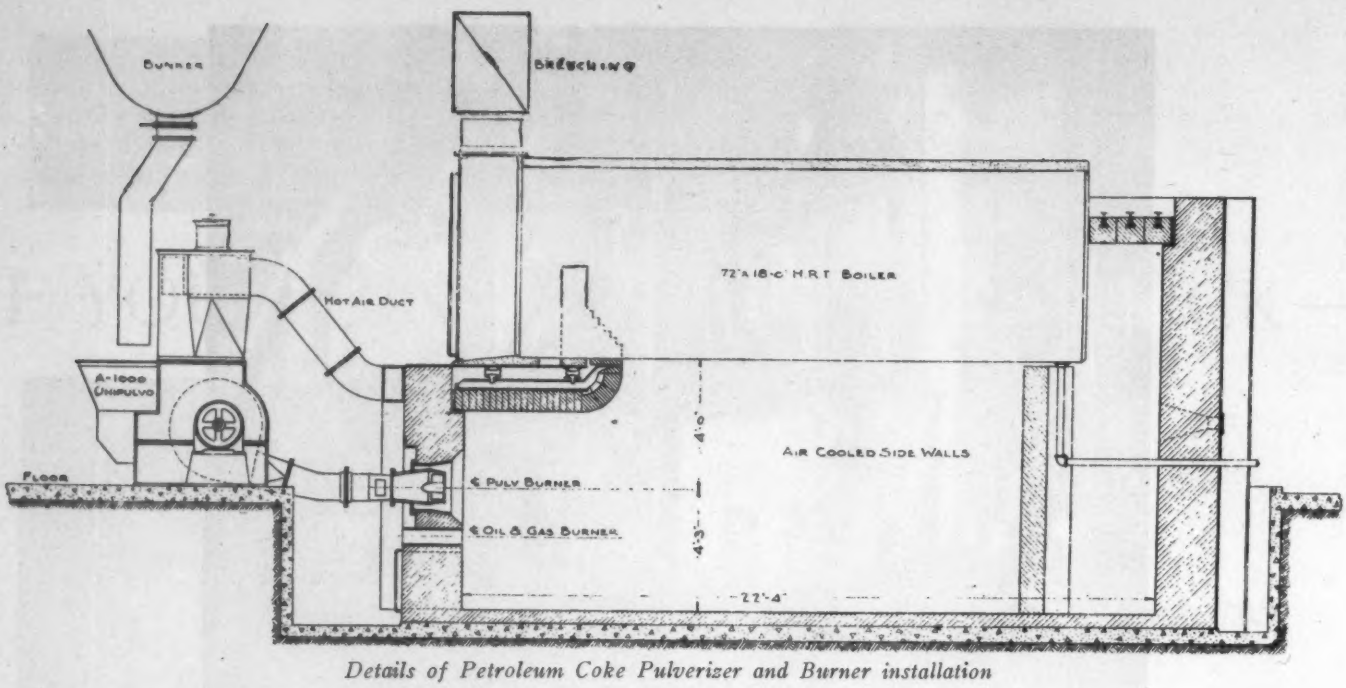
IN some cracking plants, particularly those in which the heavier fractions of the crude are processed, a considerable amount of petroleum coke is formed; in some cases as much as 60 pounds of this material may be produced per barrel of oil charged to the still. A refinery cracking several thousand barrels of oil per day may soon find itself with a large supply of coke on hand, unless a means of utilizing or disposing of this product has been provided. Such was the case at The Paragon Refining Company not long after two Dubbs cracking stills were put into operation, cracking 24 to 28 gravity still bottoms. Some of the coke produced was marketed through a local coal dealer as domestic fuel, but this demand was insufficient to absorb the amount being produced.

In removing and subsequent handling of this product, a large percentage of braize is formed, due to the friable nature of this type of coke, rendering a large portion unfit for the ordinary use. Our problem was to find a means of utilizing or disposing of the excess, particularly the large amounts of coke braize. Two methods suggested themselves, one to make briquettes of the fine material and market them as high grade domestic fuel, or second, to use the product ourselves in its pulverized state. We tried burning this product on our stokers with little success. This is to be expected, inasmuch as this coke contains but a very small percentage of ash and consequently no protection is afforded the metal of the grates when the fuel burns, resulting in very short life to the grate bars. Even a small percentage mixed with coal caused trouble on our stokers; though this may have been more successful if adequate provision had been made to intimately mix these two products. However, if the trouble with the rapid deterioration of the grates was corrected, the large percentage of fines would give rise to excessive sifting loss.

We conducted some experimental work relative to the possibility of making satisfactory briquettes for domestic use and secured some promising results. This would, however, entail a considerable initial investment and necessitate our entrance into a field with new and entirely different problems. Realizing this, we were reluctant to follow this course and devoted our time to the simpler solution, that is, using it as a pulverized fuel. The results obtained from the small amount of work we completed, did indicate to us that an excellent fuel, with many advantages over the ordinary, could be produced from this product. It is quite probable that this means of utilization will develop an important market for a large percentage of petroleum coke in some of the favorable localities. Several of the larger companies are now conducting experiments along this line and in at least one case, the briquettes of petroleum coke have been marketed.

CHARACTERISTICS OF COKE

Two typical analyses of petroleum coke, one of a sample produced during a residuum run and one non-residuum are given on following page:



Details of Petroleum Coke Pulverizer and Burner installation

RESIDUUM COKE		NON-RESIDUUM COKE	
Moisture	0.375	Moisture	0.35
Ash	1.90	Ash	0.67
Volatile	11.65	Volatile	18.89
Fixed Carbon	86.45	Fixed Carbon	80.44
Sulphur	1.00	Sulphur	1.10
Heating Value—15,400 B.t.u.		Heating Value—15,450 B.t.u.	

The two analyses given above show no very noticeable variation in the composition of the two types of coke, in fact other analyses have shown a closer relationship than indicated above. In spite of this, however, we have found a very marked difference in their characteristics during combustion, either as a solid fuel used on grates or in its pulverized state. Non-residuum coke burns much more rapidly and will produce a higher localized furnace temperature, burning under the same conditions.

Burning this material on grates requires much more caution to prevent excessive temperatures than in the case of residuum coke. Non-residuum coke does show an increase in the percentage of volatile matter and a lesser amount of ash, but it does not appear reasonable that this variation in composition is enough to account for all of the difference in their burning characteristics. It is conceivable that the chemical composition of the volatile matter may be altered with the change in operation of the process, that is necessary to produce these two different types of coke. It may be possible that the volatile in the non-residuum coke consists in part of some substances which vaporize at a lesser temperature and are ignited more readily than in the case of residuum coke. This difference could be accounted for in the method of operation; in the case of a residuum run, the residuum oil percolating through the mass of coke may remove some of the lighter substances that would remain in the case of a non-residuum run. This view, however, is not supported by any data, but only a supposition based on observation.

Hydrate of lime is injected with the charging stock to reduce corrosion in the various parts of the equipment of our cracking unit and this material or its derivatives probably contribute largely to the percentage of the ash in the coke. Operating the cracking plant to produce residuum, the amount of petroleum coke formed has been as low as four pounds for each barrel of raw oil charged to the still, while 50 pounds or more is produced in a non-residuum run. Approximately one-eighth pound of lime is used per barrel of raw oil and naturally the amount it contributes to the ash forming materials in a non-residuum run is small in comparison with the residuum method of operation. In either case, however, it can be seen that the percentage of ash is far less than for the best grades of coal. The heating value of petroleum is of course, consistently higher than coal.

Petroleum coke has certain properties, which are an asset when used as a powdered fuel. The ash content is extremely low and therefore, a boiler may be kept on the line a much longer time as far as ash removal is concerned, and being of a very friable nature, it is pulverized easier than coal, resulting in lower power consumption and longer life to the crusher hammers.

The percentage of volatile matter in this product would indicate that there would be difficulty in keeping the flame ignited. While it is true the ignition does not take place as readily as some high volatile coals, with a few adjustments and precautions, there is no trouble in maintaining a good flame. We are having gratifying results on our 150 horsepower return tubular boilers, which should be one of the most difficult boiler applications.

It has been suggested that the structure of the particles must play a part in flame propagation, where the percentage of volatile matter is small. It is conceivable, for example, that anthracite, regardless of how finely it may be reduced, consists of hard dense particles and that there is not sufficient volatile present to open up the particles as the temperature increases so as to render it more susceptible to oxidation. This may explain why anthracite is difficult to burn in its

pulverized state, requiring a greater degree of fineness and a much higher furnace temperature. Petroleum coke, on the other hand, is of a porous and sponge-like nature and it is probable that it is so even in its finely divided state that it is easily affected by the furnace gases and has a much higher rate of flame propagation.

The difference in the character of the volatile matter in coal and petroleum coke may also account for the fact that coke will ignite much more readily than coal of an equal percentage. Apparently the volatile matter in petroleum coke consists largely of asphaltic compounds, which are liquids at a relatively low temperature. This material may be driven to the surface of the particles at a moderate temperature, rendering them much easier for ignition. In burning this coke in lump form on the ordinary grate, one can easily detect this oily material being driven out of the lump and bursting in flame, which indicates that the same may occur in its finely divided state.

COKE AS BOILER FUEL

In November, 1928, the first installation for burning pulverized coke was made under one of the boilers, using a "Unipulvo" unit. This unit has since been in almost continual operation. This was followed by a second installation in the following May, then the third in July and a fourth in October. The bulk of the load is now being carried by these four boilers. There still remains four boilers equipped with stokers, burning coal. Two of the boilers burning pulverized fuel have Bigelow-Liptak air cooled walls and the other two settings have solid walls. The solid walls show no sign of deterioration at this date. In the hollow wall settings the suction of the fan of the unit pulverizer is connected to the air space, thus drawing the air for combustion through this space, cooling the setting and preheating the air.

Preheating the air is particularly an advantage during winter and rainy weather, when the moisture in the coke may run high. The two boilers with solid walls are connected with the air space of the two previously mentioned settings so that preheated air may also be supplied to them. The sectional drawing shows the unit pulverizer hookup with the ignition arch, etc. The photograph gives an idea of the interior appearance of the boiler room.

The screen analysis of the two samples taken from one of the pulverizer units is given below, sample No. 1 shows the results with new hammers in the mill and Sample No. 2 after the hammers have been in use about 90 days and just before replacing with new ones.

SAMPLE NO. 1

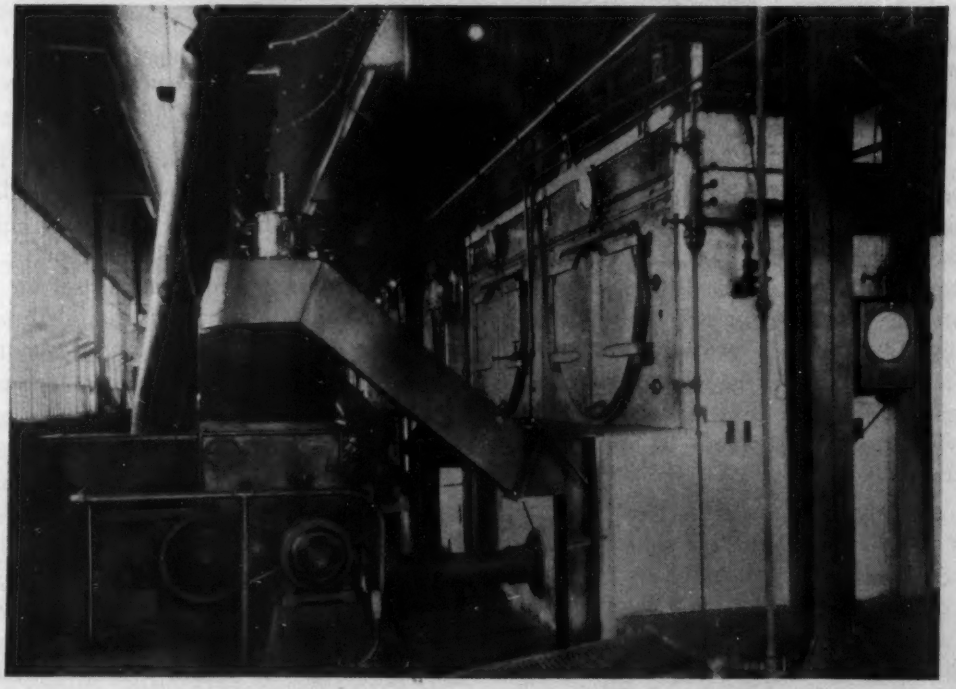
Per cent through 20 mesh	100.00
Per cent through 40 mesh	99.92
Per cent through 60 mesh	98.97
Per cent through 80 mesh	92.91
Per cent through 100 mesh	82.20

SAMPLE NO. 2

Per cent through 20 mesh	91.97
Per cent through 40 mesh	79.66
Per cent through 60 mesh	70.68
Per cent through 80 mesh	61.37
Per cent through 100 mesh	54.17

The maintenance cost on the pulverizer units has been small up to date, being confined almost wholly to replacement of hammers in the mills. The cost of replacing a new set of hammers, including labor, is approximately $10 and the average life of a set is about 90 days.

More than a million tons of this coke is produced each year and in some localities large piles have accumulated. Inasmuch as this product has many desirable characteristics, which give it some advantages over the average grade of coal, with more experimental work, this product will be converted from a material difficult to dispose of to a valuable by-product of the oil refining industry.



Coke Pulverizer installation showing motor drive and method of connection to furnace, at Paragon Refining Company plant, Toledo, Ohio

Long Periods on Stream Accomplished by Special Equipment and Operation

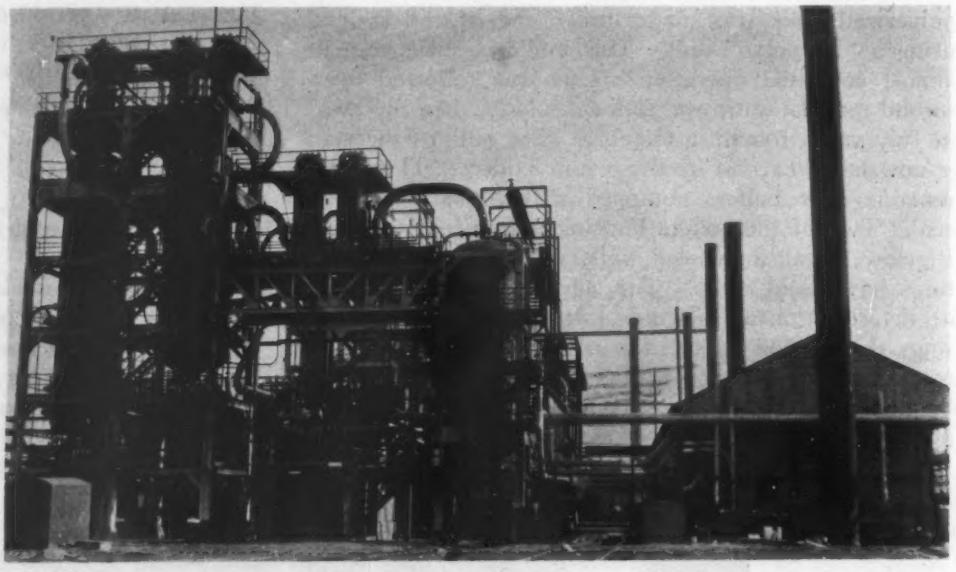
By GEORGE REID
Associate Editor

RAPID strides have been made during the last few years in the design and fabrication of cracking plant equipment. In both appearance and efficiency the modern liquid phase cracking unit of a given type bears but little resemblance to units of similar type erected five years ago. Refinery engineers, now familiar with the needs of the cracking art, are designing more effiicient furnaces and tubular coils; they have perfected fractionating columns which are positive in their rectification and subject to absolute accuracy of control. Auxiliary equipment, such as modern hot oil pumps, control instruments, and refractory materials and means of firing, have been subjected to much improvement. Exchange equipment utilizes heat formerly wasted and in many instances such devices are employed in fractionation of heavier products. And with the ever improving equipment and operation has come lower operation costs.

The problem which has been most annoying has been one of keeping the unit on stream. Frequent shut-down periods for cleaning out coke contribute much to the cost of the cracking operation, since the shut-down cracking coil is earning no money and overhead expense, other than actual operating costs, continues just the same. It is safe to say that the average cracking process operating in the liquid phase is operated in cycles ranging from one to three weeks on-stream, occasionally longer, which cycles are governed by the type of process, the charging stock, and local operating conditions. It is usually necessary to clean out the chambers provided for coke accumulation at intervals ranging from periods as short as 48 hours to one week. There are many nine-day operating cycles, and also many cycles of three weeks duration. Usually shut-down periods range from 10 to 15 hours to 25 and 30 hours.

Standard Oil Company of Ohio, at its No. 1 refinery at Cleveland has designed its four cracking units for long cycles of operation and has included in the design and construction of these units additional coke accumulator chambers which permit average cycles, or on-stream time, of 2000 hours. After 84 days or 12 weeks, of operation each of the four Tube and Tank units are shut-down, thoroughly and minutely inspected, any or all precautionary repairs or replacements made, and again placed in service.

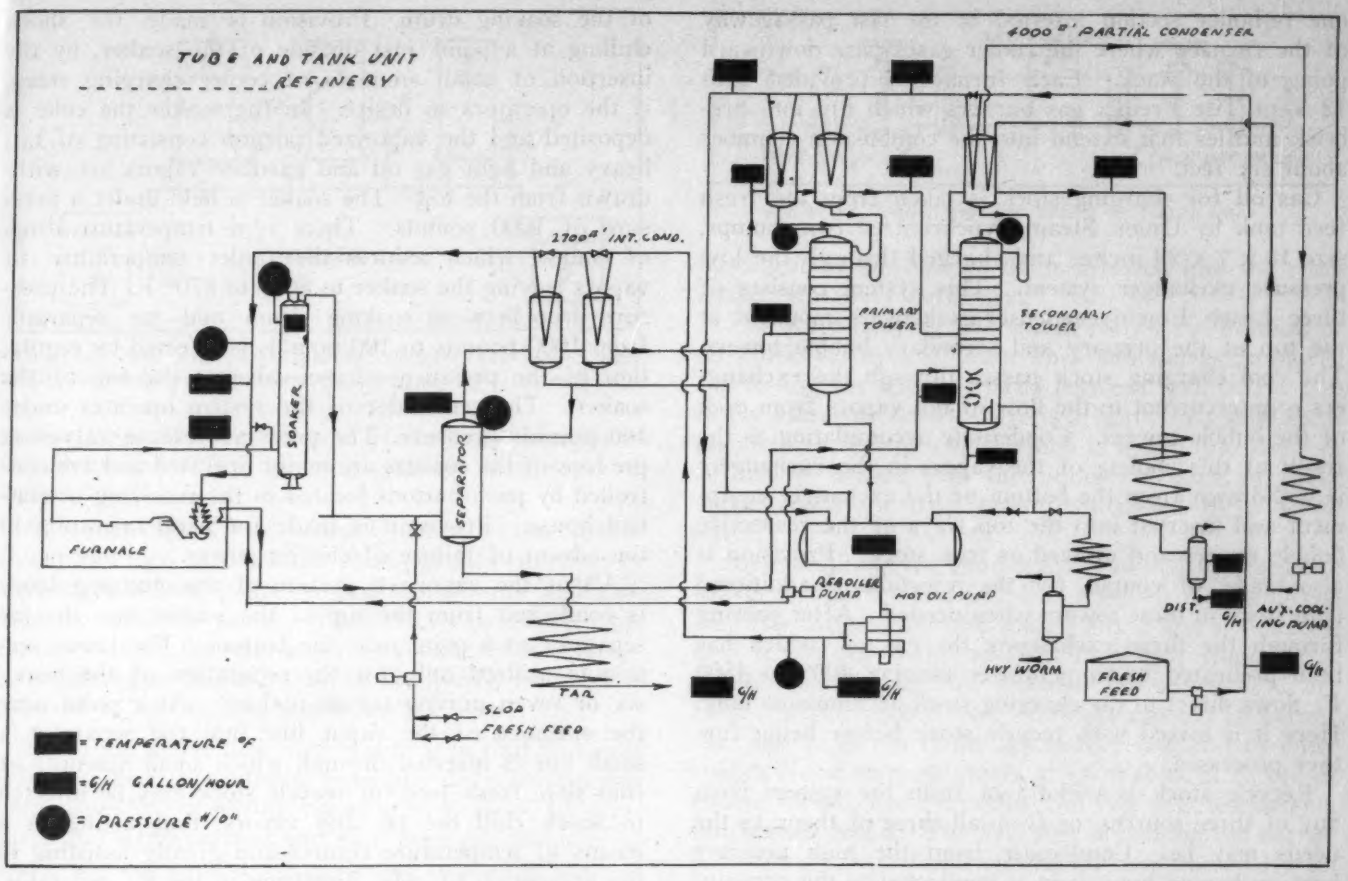
About two years ago this company began operating its first modern cracking installation which consisted of two units, each having a charging capacity of 2250 barrels of gas oil daily. Basically the units were the standard type developed by Standard Oil Company of New Jersey, although they were modified and adapted to produce the particular results desired by Standard Oil Company of Ohio. They were designed to operate on gas oil and to produce gasoline of high quality at lowered costs.



Standard Oil Company of Ohio, Cleveland, constructed and designed the cracking units to operate on average cycles of 2,000 hours. This photo shows the two units lately completed and placed in operation

A combination of factors contribute to the low manufacturing costs, which include the yield service factor, which is high; the useful life of the equipment, and the cost of labor and fuel. It is reported that at one time the developers of this process set an ideal cost figure for putting 100 gallons of gas oil through the process, and that these four units are processing gas oil at but slightly more than one-half of that figure.

The original two-unit installation was equipped with three soaking drums or reaction chambers for the accumulation of coke. This practice contributed largely to the very long operating cycles, since the third soaking drum could be cleaned out, while the other two were in service. The plan of installing the third soaker was so successful that when the company decided to erect a second installation of two cracking units, which has recently been completed and placed in operation, the third or "extra" soaking drum was included in the design. The practice assists greatly



in getting away from frequent shut-downs, and even though each soaking drum involves the expenditure of over $23,000, the company officials deemed it good policy to provide the additional equipment. With cycles of operation running 84 days and with a gasoline yield of about 60 per cent, which requires no chemical treatment other than a caustic wash as it comes direct from the unit, and further, which sells readily at a premium when Ethylized to standard specifications with but a small amount of the Ethyl fluid, there can be no doubt of the farsightedness of those responsible for the provision of the third soaking drums on each of the two unit installations. Twelve week cycles are cost reducing cycles. There are many atmospheric distillation units in this country which are shut down for cleaning as often as every 90 days. At this plant it is the practice to clean the soakers about every 10 days, but because of the third soaking drum, the coil and fractionating equipment are not interrupted.

The newly completed cracking units were designed to operate at somewhat higher pressures and temperatures than was the original installation. The older units, for example, are operated at 750 pounds pressure in the soaker, while the new units carry 1000 pounds pressure at this point. It is the newer installation with which this article is concerned, however, and they will be described.

The new complete unit is made up of the following: The cracking coil furnace which is built in four sections and with one reboiler section. Three low pressure shell and tube Leach Fractotype heat evchangers and two high pressure exchangers of the same type, comprise the equipment provided for utilization of the heat in the vapors. A horizontal accumulator tank with dimensions eight by 30 feet and a vertical tar separator vessel 10 by 30 feet. Two 14,000-gallon-per-hour hot oil pumps with water cooled pistons. Three soaking drums, each five by 40 feet in dimensions, with walls 5½ inches thick, forged from solid steel billets, and weighing 125 tons each. A primary bubble tower, size 10 by 40 feet, and a secondary bubble tower, size nine by 40 feet. In addition, of course, are the usual departments and their auxiliary equipment as required in liquid phase cracking operations.

LOW FURNACE TEMPERATURE

Something of the high service factor is indicated by the experience with the cracking coils used in the first two unit installations. These cracking coils consist of 4½-inch hot rolled seamless tubing with 9/16-inch wells, providing 4700 square feet of heating surface divided into one radiant section, two convection sections, and one preheater section. There are also two reboiler sections placed like economizers in the flues where the cooler gases of combustion pass enroute to the stack. During the two years of operation it has not been necessary to make repairs to refractories or tubes with the exception that a few of the tubes have been removed because the operators were not certain that they had been properly gauged. The long life of tubes and furnace linings may be attributed largely to the fact that the furnace operates at the relatively low temperature in the combustion chamber of about 1300° F.

In the new two-unit installation alloy steel tubes are used of Babcock and Wilcox type known to the trade under the name Enduro KA-2. The heating surface is similarly divided into a radiant section, two convection sections and a preheater section. There is but

one re-boiler section inserted in the last passageway of the furnace where the cooler gases pass downward going to the stack. Each furnace is provided with 12 Vent Tite Premix gas burners which fire into firebrick muffles that extend into the combustion chamber about six feet.

Gas oil for charging stock is taken from the fresh feed tank by Union Steam, synchronized twin pumps, size 13 x 7 x 20 inches and charged through the low pressure exchanger system. This system consists of three Leach Fracto condenser-exchangers mounted at the top of the primary and secondary bubble towers. The cool charging stock passes through the exchangers countercurrent to the flow of hot vapors from each of the bubble towers. Condensate accumulating as the result of this cooling of the vapors in the exchangers is withdrawn from the bottom of the exchanger equipment and inserted into the top trays of the respective bubble towers and utilized as trim stock. Provision is also made, of course, for the injection of additional trim stock in these towers when needed. After passing through the three exchangers the gas oil, which has been preheated to temperatures ranging 400° to 450° F., flows direct to the charging stock accumulator tank. Here it is mixed with recycle stock before being further processed.

Recycle stock is withdrawn from the system from any of three sources, or from all three of them, as the needs may be. Condensate from the high pressure heat exchanger equipment is conducted to the accumulator tank for recycling through the system as are the bottoms accumulating in the primary bubble tower. Bottoms from the secondary bubble tower may either be taken to the accumulator for recycling or withdrawn from the system, cooled, and marketed as a low cold test furnace oil. The ratio of fresh feed to recycle stock is determined by technical control of the operation, and based on experience and products required.

FUNCTIONS OF EXCHANGERS

The blended charging stock in the accumulator is picked up by a large Union Steam synchronized twin pump operating under automatic control as well as remote control from the receiving house. This pump discharges into the high pressure heat exchange system and to the cracking coils. The two high pressure exchangers, are located between the tar separator and the primary bubble tower. The exchangers have two functions, they are employed to preheat the incoming charging stock to a temperature slightly above 600° F., and are employed to condense much of the recycle stock which is withdrawn from the bottoms of the evchangers and conducted to the accumulator tank. Further, the bottoms from the exchangers may be diverted to flow back into the top of the tar separator and act as trim control of that equipment.

Charging stock enters the coils at about 625° F. preheat and at 1400 pounds coil inlet pressure and at the rate of around 18,000 gallons "hot" per hour, which averages around 15,000 gallons "cold" per hour as the charging rate. In its travel through the preheater bank, radiant and convection tube banks, the oil is raised in temperature approximately 300 degrees to have a coil outlet temperature of 915° to 920° F.

From the cracking coil the oil is taken to the bottom of the soaking drum. Provision is made for shock chilling at a point just outside of the soaker, by the insertion of small amounts of cooler charging stock, if the operators so desire. In the soaker the coke is deposited and the vaporized portion consisting of tar, heavy and light gas oil and gasoline vapors are withdrawn from the top. The soaker is held under a pressure of 1000 pounds. There is a temperature drop, of course, which reduces the outlet temperature of vapors leaving the soaker to 865° to 870° F. The pressure drop between soaking drum and tar separator from 1000 pounds to 100 pounds is effected by regulation of the pressure release valve at the top of the soaker. The remainder of the system operates under 100 pounds pressure. The pressure release valves at the tops of the soakers are motor operated and are controlled by push buttons located in the receiving or control house. Provision is made for hand operation in the advent of failure of electric power.

All of the vaporized portion of the charging stock is conducted from the top of the soaker into the tar separator at a point near the bottom. The lower section is utilized only for the separation of the heavy six or seven gravity tar or fuel oil. At a point near the entrance of the vapor line into the separator a small line is inserted through which small amounts of cold slop, fresh feed, or recycle stock may be injected to shock chill the tar and vapors, thus acting as a means of temperature control and greatly assisting in the prevention of coke formation in the tar separator. In fact there is no coke formation in the separator. The low gravity tar is an excellent, highly viscous, and low cold test fuel oil. The tar is removed continuously from the bottom of the separator under the pressure in the fractionating equipment.

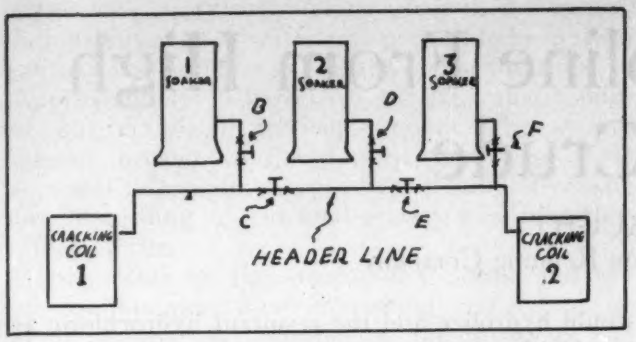
Vapors released from the tar pass upward through several disc and doughnut plates. Leaving the separator the hot vapors pass through the two high pressure exchangers, giving up part of their heat, and then pass into the primary bubble tower.

RECTIFICATION

In their passage through the 10 bubble trays in the primary bubble tower counter current to the downward flowing condensate from the low pressure exchanger equipment as previously discussed, the vapors are rectified to contain only gasoline and light gas oil, leaving the heavy gas oil behind to accumulate in the bottom of the tower. The heavy gas oil is then conducted to the accumulator tank for recycling.

The remaining vapors pass through two of the low pressure exchangers of partial condensers of Leach type, and flow into the side of the secondary bubble tower, which also contains 10 trays. In the lower section of this bubble tower the light gas oil is accumulated.

This material is picked up by a pump having suction on the bottom of the tower and under automatic control it circulates the light gas oil through the reboiler section provided for such purpose in the furnace, and back into the side of the bubble tower. This serves to strip the gas oil of any light ends which may be entrained in it. The stripped gas oil is then removed from the wier section on the opposite side of the tower and taken either to cooling coils and accumulator for



Cracking coils and three soakers, showing the piping and valve arrangement, Standard Oil Company of Ohio refinery

marketing as furnace oil, or it is conducted directly to the accumulator for recycling through the cracking system.

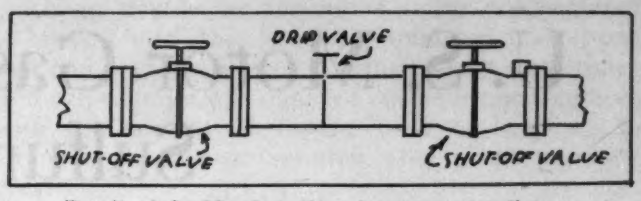
Gasoline vapors rise upward through the bubble tower and pass through the third partial condenser or exchanger before going to final condensers and gasoline accumulator tanks. The reflux condensate from the bottom of the exchanger is conducted to the appropriate upper bubble tray in the tower where it is inserted to act as trim stock for the tower.

From the above description it is seen that this unit was designed for extreme flexibility as provision has been made for operating under a wide range of pressures and temperatures, and each piece of exchange or rectifying equipment is capable of change in control and use. Further the condensates from a number of sources about the plant as described, may be employed for any one of several purposes, or withdrawn from the system, either without seriously affecting the remainder of the system.

Primarily the units are designed to produce only gasoline, tar, and coke, although there are times when the light gas oil fraction from the secondary bubble tower may be profitably marketed as furnace distillate. The gasoline produced has an initial boiling point of about 88 and an end point of 410 degrees in the winter time. The gasoline from this cracking operation, which, incidentally, utilizes gas oil from Mid-Continent crude delivered in Cleveland by pipe line, has a very low gum content. As previously stated, the anti-knock valve of the product as yielded is very high.

SWITCHING SOAKERS

The header and manifold system employed in switching from one soaking drum to another while the unit is in continuous operation at 1000 pounds pressure is of interest. A series of heavy forged steel valves designed for the operating pressures are provided on the header line leading from cracking coils to the three soakers and on the lines leading to the soakers from the header. Through the manipulation of these



Detail of double shut-off valves on vapor lines

block valves the flow of oil is diverted into the clean soaker whenever necessary.

The accompanying line sketch shows the location of all block valves and drain lines and valves employed for testing for leaks. Placed between each of the two heavy valves as shown there is a heavy cast steel spool about three feet in length which is bolted into the line. A drip is drilled into the middle of each of these spools with the drip outlet controlled by a small valve.

An example of the procedure in switching from one soaker to another is detailed as follows: Cracking coil No. 1 is discharging into soaker No. 1 and it is necessary to cut out of this soaking drum into drum No. 2. While running into No. 1 soaker the valves at C are closed in the header line. They are opened to permit the flow to go on down the header line and to enter soaker No. 2 through valves at D. Valves at E, are of course, closed, since cracking coil No. 2 is discharging into soaker No. 3. The first step in making the change is to close valves B and opened the drip valve between them. If there are no leaks, valves at E are closed, the drip valve between valves C is closed and valves C are opened. The drip valve in the spool between valves D is closed and valves D are opened, which permits coil No. 1 to discharge into Soaker No. 2 with the valves at B closed, soaker No. 1 is out of service and ready for cleaning.

When a soaker is taken out of service for cleaning the coke, then the pair of valves on the line leading from the main header line to that soaker, in this example above this would be valves at B, are disconnected at the flange nearest the soaker. A blank of heavy steel is bolted in place over the opening in the line. This practice eliminates any hazard which might be brought about by leaks, and makes the soaker safe for the workmen cleaning out the coke.

The simplicity of the arrangement and the ease with which the change from soaker to soaker can be made are the chief advantages of this system. When it is necessary to change soakers at night, for example, the usual gang of pipe fitters are not required, since the men on shift in charge of the cracking units simply manipulate the proper valves and leave the cut-out soaker cooling until morning. Each soaker is cleaned about every seven days. That means there is 12 clean-outs for every 2000-hour run, and without interruption of the operating cycle.

U. S. Motor Gasoline From High Sulfur Crude

By C. B. FAUGHT
Superintendent, Richardson Refining Company

A HIGH anti-knock gasoline that meets all U. S. Motor specifications, manufactured from sour crudes, was considered an impossibility when the major West Texas fields were discovered. Methods have been established which reduce the mechanics of refining and treating these crudes to fairly simple routine. The operation involves more expense than that of sweet crude, and requires more time as well as more chemicals. The trick has been to find methods that would give uniform results on each successive batch. Once the routine is established, it is as simple as with any crude.

This paper is devoted to a study of the problems encountered and the methods used in treating gasoline from Roberts, Henshaw and Chalk crudes. This has been no easy matter as in this territory four refineries operating on these crudes are using four different treating processes. All four are apparently successful, yet through an interchange of information it seems that each has been unsuccessful when trying to apply the process of the other. Why this is true has not been definitely determined. Differences in distilling equipment probably account for most of the variable results.

In our work, we assumed from the beginning that our major sulfur problem was centered in the hydrogen sulfide content of the crude. This was proven correct in a series of attempts to remove the sulfur from the crude before processing. Results proved that only the volatile sulfurs were taken out in this treatment. A composite of the crude showed a sulfur content of 1.54 per cent.

Fractionating the crude after the removal of the hydrogen sulfide produced a hydrogen sulfide free gasoline. The sulfur content on this gasoline cut was exactly the same as the sulfur content on a gasoline fraction taken from the same crude before the crude had been treated and after the fraction had been washed free of hydrogen sulfide with a caustic wash. In other words, in treating the crude for reduction of sulfur, the net results were the removal of the hydrogen sulfide. This was a very difficult procedure as the crude emulsified very readily to all aqueous solutions and could not have been repeated on a commercial scale.

We dismissed the idea of freeing the crude of its sulfur and worked along the lines of handling the products of distillation in an economical manner.

NEUTRALIZING NECESSARY

Our first consideration naturally was the effect of the sulfur compounds on the equipment. A small amount of sodium and magnesium chlorides were present in the crudes. These salts, if allowed to pass through the pipe still without being neutralized, would hydrolize and the resultant hydrochloric acid would give serious trouble as it would eat up the equipment and, more important, would give an off colored gasoline which is very hard to treat.

Experimenting with hydrated lime, chemically manufactured, showed that the lime would not only keep the exchangers free of salt deposits, but would neutralize all of the salts present. These two items taken care of, permitted study of the major problem of hydrogen sulfide.

This gas does several very unconventional things. If allowed to distill off without neutralizing, it will be certain death to any employees who come in contact with it in concentrated form. In weaker form it irritates the eyes and produces prostration and physical complications.

If allowed to set in the gasoline, it treats very unsatisfactorily and with higher final sulfur contents of the gasoline.

If not neutralized, very active corrosion of equipment takes place, very noticeably after the condensing temperature of the gasoline is reached.

If the hydrogen sulfide gas was entirely neutralized in the process of distillation, the resultant gasoline stream was sweet to the lead acetate test and was non-corrosive, giving a perfect strip when boiled for several hours. The gasoline was sweet, and would show no reaction on metals. This simplified our problem considerably as we knew that the use of caustic solutions would neutralize the sulfide gas either in the vapor phase or after it has been redissolved in the gasoline stream.

Two 50-barrel tanks were set up so that the gasoline stream would pass through them in series after it left the condenser box before it entered the run down tanks. Two small centrifugal pumps were placed in a pit below the level of the two tanks and caustic was charged into the bottom of the tank nearest the receiving house and pumped from there into the vapor line just before the condenser coils. The second small tank caught any caustic that was carried over from the first tank. This prevented the caustic from getting into the run tanks.

Anhydrous ammonia was tried in an experimental way, but results were unsatisfactory. The gasoline was hard to treat and the color was not as good as with caustic. Ammonia has its bad points in this procedure. An excess will be dangerous to the workmen and will corrode the equipment. It is more expensive than either caustic or soda ash solution.

Various concentrations of caustic solution were used. The ideal make up was 18° Be. Weaker solutions were spent too quickly and stronger solutions settled out in the coils. This was due to the formation of concentrated solutions of sodium sulfide. This

reaction was continually taking place in the weaker solutions but enough water was present to keep them weak and the sulfide was washed out of the coils.

Approximately 20 barrels of 18° Be. caustic solution was circulated for eight hours. The stream gradually became sour, but only slightly so. Our object was to completely spend each dump of caustic before discarding it. The final gravity was invariably 6° Be. to 7° Be.

Hourly tests on the stream of gasoline and the weak solution gave some interesting data over a period of months. We worked on the theory of the once pass theory, or completely spending the caustic on the first contact with the vapors. This was not successful. Perhaps with equipment built to furnish intimate contact for the proper length of time this would be economical.

This stream kept sweet treated without further use of caustic before the doctor treatment.

HYDROGEN SULPHIDE DISSOLVES IN WATER

However, a later experiment using cold water instead of caustic solution was successful in removing a major portion of the hydrogen sulfide gas, leaving a distillate that sweetened readily to lead acetate on adding a small amount of caustic just prior to the doctor treat. The water removed danger to operating men and other workmen about the plant.

Hydrogen sulfide dissolves very readily in cold water. We have an abundance of water at approximately 70°F. Figures have been published from time to time showing the absorbing capacity of water at various temperatures. We use the same equipment with the water as was used with the caustic solutions. Naturally the water must be changed at intervals of two to three hours.

Tests on the stream showed the following sulfur contents:

Straight run—	Sulfur	Gum
Without treatment	.45 per cent.	75 Mg/100cc
Caustic sweetened	.18 per cent.	21 Mg/100cc
Water washed	.26 per cent.	35 Mg/100cc

The next problem was doctor treating. Our equipment consisted of two 2000-barrel agitators, originally equipped with circulating pumps. A batch slightly sour to lead acetate sweetened readily on the addition of sufficient weak caustic solution merely by circulating. This primary sweetening with caustic is necessary in all cases, otherwise the lead will react with the hydrogen sulfide in the gasoline and will not sweeten to doctor, as the lead in solution is removed as lead sulfide is formed. The caustic will also remove small portions of sulfur other than that in the hydrogen sulfide.

Circulating at the rate of 1500 gallons per minute permitted the batch to be "turned over" in about an hour. Yet the batches were sour after continued circulating. The average sweetening time was 24 hours.

A small jet of air was put into the discharge of the circulating pump and the batches sweetened in approximately eight hours. It was apparent that the old method of air blowing was what we needed. We tried it and the batches treated out in an hour or so. Careful records of each batch were kept and some surprising figures were obtained.

Almost double the amount of sulfur was required to break a batch that had been circulated against one that had been air blown. Approximately eight times as much litharge was required on the former method, with the amount of caustic used to keep up to strength the doctor solution also proportionately greater.

Mixing heads were also tried but in this case about double the amount of doctor solution was needed to break a given batch, due to the fact that the doctor could not be used through the mixers again until it had been thoroughly recovered.

With these facts before us we worked out an efficient method of recovery of spent doctor solution. This is the usual procedure of heating and blowing. The doctor can be recovered and used indefinitely, provided the recovery is complete each time and sufficient lead and caustic are added from time to time to keep up the concentration and gravity. Recovered doctor treats much more rapidly than new doctor.

This recovery naturally requires more time than with sweet crudes, and is more expensive. Naturally it requires more attention and care. The maximum distribution of air in the recovery tanks is a distinct advantage.

Another fact discovered in treating these gasolines was that the sulfur content of the gasoline was at a minimum when the batch was sweet to doctor but before the addition of the free sulfur for the break. Various sulfurs were tried but the results were the same.

Straight run gasoline sweet to doctor before adding sulfur, .14 per cent. sulfur.

Straight run gasoline sweet to doctor after adding sulfur, .18 per cent. sulfur.

The exact reason for this has not been discovered.

TREATING CRACKED PRODUCTS

So much for the straight run. Pressure distillate from the Jenkins units treated much the same way except that instead of being 30 plus, only 18 to 20 was obtainable. Acid treatment was necessary, followed by rerunning in a pipe still. This gave a finished gasoline meeting all of our requirements.

Since the sulfur on the straight run was not under .10 per cent. we decided to acid treat both grades. As in the doctor treatment, the distillates were first entirely freed of hydrogen sulfide and then acid was applied. The straight run and pressure distillate treat with better results when handled separately and blended for rerunning.

	Sulfur	Gum
Jenkins P. D. before treatment	.30	150
Jenkins P. D. after acid treatment	.25	150
Jenkins P. D. after rerunning	.08	10
Jenkins P. D. sweet to doctor	.09	10
Blended stocks sweet to doctor after running..	.09	10

Treatment of the pressure distillate is easier than the straight run, although it requires slightly more acid. This is due to the difference in the formation of sulfur compounds. Both stocks will treat and rerun to a 30 plus color, fairly stable during the summer months and the gums do not form more rapidly than in any other gasolines. Samples placed in dark rooms for four months showed the same gum and sulfur content as the original tests.

General view of combination plant, with Gray Polymerizers and Cross fractionating equipment in foreground; crude oil fractionating columns in background. Waverly Oil Works Company, Coraopolis, Pennsylvania

Flexibility Secured in Combination Cracking and Skimming Unit

By GEORGE REID
Associate Editor

WAVERLY Oil Works Company, at its Coraopolis plant, about 15 miles out of Pittsburgh, has combined skimming and cracking operations in one installation. This combination of cracking and crude oil fractionating equipment was designed as a solution to local problems at the plant involving conservation of ground space, the need for isolation of straight run gasoline from cracked products, and a desire to crack either heavy residual oil or overhead distillates, or both. The unit, which requires only an area of 125 by 140 feet, consists of a Cross cracking unit, crude fractionating equipment, Gray polymerizing towers, a continuous chemical treating system, and a small auxiliary pipe still.

In this installation it is possible to operate either as a cracking still alone, or simultaneously with crude oil, with the crude furnishing all of the stock for cracking, or additional cracking stock may be added as desired.

The cracking unit consists of a special pipe still equipped with a conventional Cross reaction chamber, an evaporator or flash tower, a bubble type fractionating column and two Gray vapor phase fuller's earth polymerizers.

The crude distillation equipment consists of suitable heat exchangers, pancake coils in the tops of the Cross plant evaporator and bubble tower, and a flash or evaporator tower followed by a bubble tower for fractionation, together with a small auxiliary pipe still.

Two connecting links are provided to tie together the skimming and cracking departments of the twin-installation. The "mixing tank," which is a horizontal insulated vessel in which the topped crude and recycle stock from the Cross bubble tower accumulate to furnish charging stock for the Cross pipe still, is first. The second connecting link is the coils in the upper sections of the Cross bubble tower and evaporator in which the incoming cool crude is heated sufficient to effect the distillation of much of the light fractions through the utilization of heat formerly wasted at these points.

Cold crude is pumped through pancake coils in the upper sections of the Cross evaporator and bubble tower where it serves to partially control the tower temperature and is itself preheated. Sufficient heat is picked up in this manner to effect partial distillation of the crude. The portion of distillate from the crude is governed by the rate of charging and temperature conditions of operation. From the pancake coils the heated crude oil is taken into the crude evaporator tower which has an open space at the bottom and several bubble trays in the upper section. In one method of

operation the crude enters this evaporator somewhat above 400°F. and approximately 30 per cent of the crude is distilled.

The vapors pass through the bubble trays and through a reflux condenser, vapor line and over to the bottom of No. 2 tower of the crude fractionating system. Three streams may be taken off of this bubble tower. Under operating conditions as mentioned, the top or overhead stream is a 100°F. initial and 395°F. end point gasoline. From the side there is removed a stream of naphtha of about 216 initial and 415 end point, while a bottom stream is removed which is termed heavy naphtha with a 325 initial and 440 end point. Under another method of operation the crude would be preheated sufficiently to yield all of the gasoline, kerosene and at times a gas oil cut.

The reduced crude accumulating in the bottom of the crude evaporator tower may either be discharged to the mixing tank, or taken through the auxiliary pipe still where it can be discharged either to the Cross evaporator tower or taken to the mixing tank. When the reduced crude is further heated in the auxiliary tube still and discharged back into the mixing tank those vapors which are evolved through further application of heat are released through a vapor line leading from the mixing tank into the Cross plant bubble tower for fractionation.

The straight run gasoline produced in this manner is given a doctor treatment in the continuous treating system. The naphthas may be marketed as painters' and varnish makers' naphtha, as cleaners' naphtha, or they are blended to meet specifications of individual customers who demand special products.

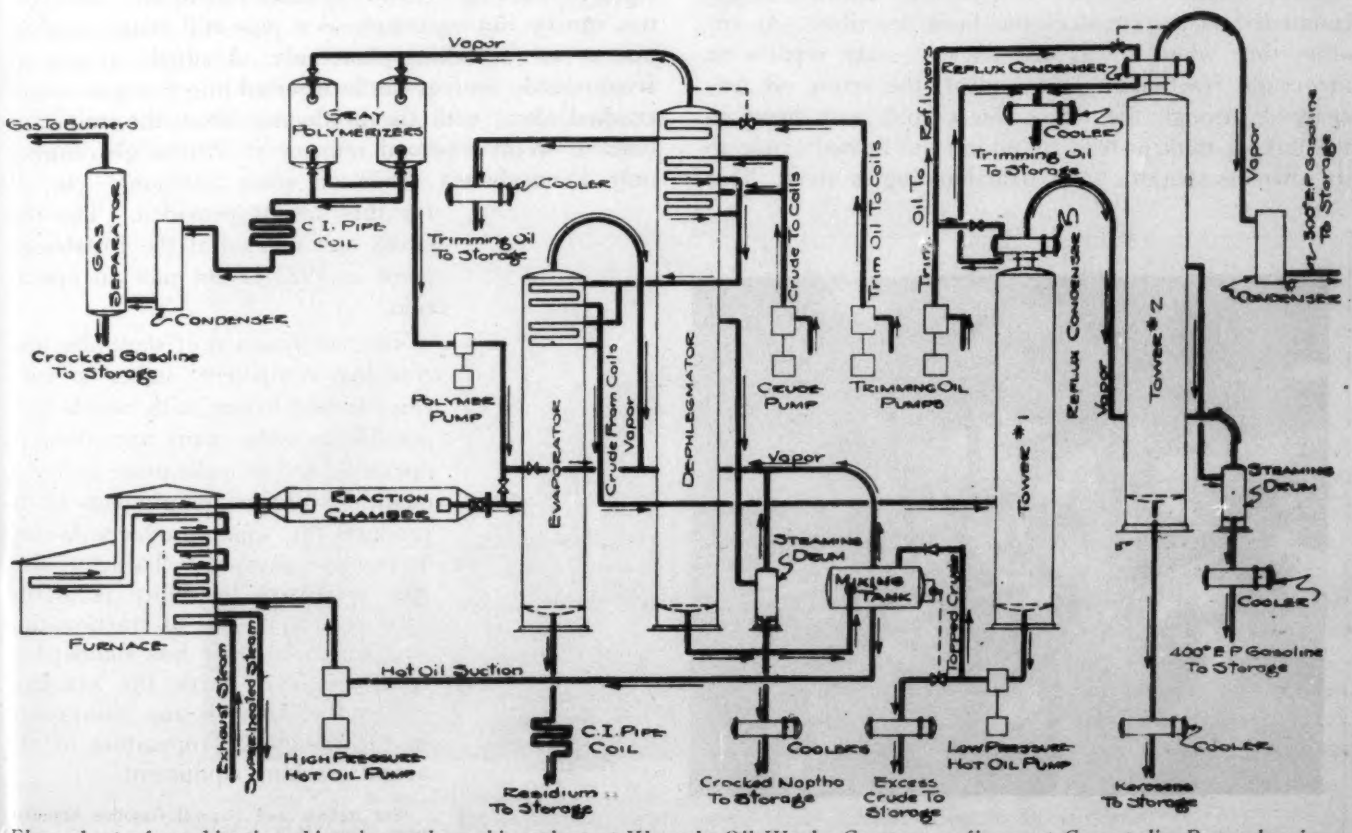
A charging stock consisting of either reduced crude and overhead distillate derived from the Cross evaporator tower and fractionating tower, or the overhead distillate alone, is taken from the mixing tank and is charged to the cracking coils by National Transit hot oil pumps. The heat imparted to the oil in the coils at the tops of the towers, and in the auxiliary pipe still when used, remains in the charging stock so that it reaches the Cross unit cracking coils at a temperature of around 610°F.

In accordance with conventional practice the oil and vapor leaving the heating coils passes into the reaction chamber, which is a horizontal vessel five feet in diameter and 40 feet in length and made of solid steel forging. At the outlet of the reaction chamber the pressure is reduced, permitting the oil and vapor to pass into the evaporator chamber at a pressure of about 40 pounds. The evaporator is fitted only with baffle plates designed to knock back the entrained heavier particles as the vapors rise upward to the vapor line to be conducted to the bottom of the bubble type fractionating column.

A side cut may be taken from the Cross fractionating column which is withdrawn into a steam jet type of flashing pot or stripping section to flash and fire specifications for a light gas oil distillate similar in characteristics to kerosene with the exception of its color, or a heavy naphtha may be prepared in this fashion.

That portion of the oil not vaporizing in the evaporator is drawn off the bottom as tar of 15 gravity A. P. I. of high viscosity and low cold test. This product is settled in a tank to drop suspended matter and is salable as fuel oil.

Vapors taken from the top of the bubble fractionating column are passed through the Gray polymerizers and are then condensed to a finished gasoline, have an initial boiling point of 90 to 95°F. and an end point of



Flow chart of combination skimming and cracking plant at Waverly Oil Works Company refinery at Coraopolis, Pennsylvania

400°F. This product is sweetened in the continuous treating system. Polymers from the Gray towers are continuously pumped back into the Cross evaporator tower or to the mixing tank for recirculation through the cracking coil, or to the Cross bubble tower. In either event the heavier portions find their way back to the cracking coil.

Bottoms accumulating in the Cross bubble tower are usually about 36 A. P. I. gravity and forms the recycle stock. It is led off to the mixing tank where it mingles with the topped crude derived from the skimming operation previously described. In this system of operation the heat in the reflux from the Cross fractionation equipment, and the heat picked up by the incoming crude is conserved, which effects a reduction in fuel costs.

Hot Oil Pumps charging mixed stocks to cracking coil

Steam is employed in small quantities in both the Cross and skimming department bubble tower. The temperature of these towers is automatically controlled by thermo-couple operated instruments which govern the rate of pumping trim stocks through coils in the tops of the towers.

This installation was erected by M. W. Kellogg Company working in conjunction with Waverly Oil Works Company engineers, and it is capable of operation under many variations of the original scheme. The method of operation where charging stock is a combination of reduced crude and whatever overhead distillate is accumulated as recycle stock has been described. At another time when it was necessary to make repairs on the crude fractionating equipment, the crude oil was charged through the Cross tower coils and direct to the mixing tank instead of taking the heated crude to its own evaporator and fractionating system. This method did not permit the isolation of cracked and straightrun products. Upon completion of repairs the unit was changed over to separation of the two products without shutting down.

Under another method the reduced crude oil from the crude evaporator tower was charged through the auxiliary pipe still direct to the Cross plant evaporator chamber from where it distilled over into the bubble tower all products including gas oil, which was accumulated in the bottom of the bubble column along with the Cross recycle stock and the two, in mixture, were taken to the mixing tank and charged to the cracking coil. Under this method the whole of the charging stock to cracking coil was overhead distillate. The system can be run separately as a pipe still crude topping unit or as a cracking plant only. A supply of gas oil from outside sources can be injected into the system and cracked along with the production from the units operation. With a second refinery at Pittsburgh running only Pennsylvania crude oil some additional gas oil for this unit is provided. The old Cross unit erected at the Pittsburgh plant in 1923 is not now in operation.[1]

Control room at Waverly's combination skimming and cracking installation

This combination of skimming and cracking equipment makes a very flexible installation with which it is possible to make many variations in operation and to make more or lesser quantities of certain products or to produce the same products having differing physical characteristics. The increased flexibility is attributed more to the use of fractionating equipment, more or less standard in type, combined with the cracking still, rather than to any innovations in the design and operation of the actual cracking equipment.

[1]See Refiner and Natural Gasoline Manufacturer, June, 1929, p 66.

High Pressure Gasoline Plant Has Unusual Features

LOUISIANA Gas & Fuel Company, Shreveport, Louisiana, after operating its high pressure gasoline plant at Alto, near Monroe, Louisiana, at its original capacity of 100,000,000 cubic feet, has enlarged this capacity by the addition of more equipment to 150,000,000 cubic feet. This plant is thought to be the largest high pressure installation in the country. It is designed to handle gas at pressures ranging from 600 pounds as the maximum to a minimum of 300 pounds per square inch.

The gas is supplied to the plant from wells in the Richland Parish field. The average gas passed through the plant contains from 275 to 300 gallons of gasoline per million cubic feet. After passing through the absorber the gas is delivered at full pressure to pipe lines for distribution.

The complete plant was erected for the operating company by the Stearns-Roger Manufacturing Company under the supervision and according to the design of J. A. Campbell Company, Long Beach, California. Included in the construction work was the absorption plant proper, pipe lines for transporting gasoline to the loading rack five and one-half miles away at Archibald, Louisiana, and for conveying absorption oil from the rack to the plant, as well as gasoline storage, loading rack and a loading vapor recovery system at the rack site.

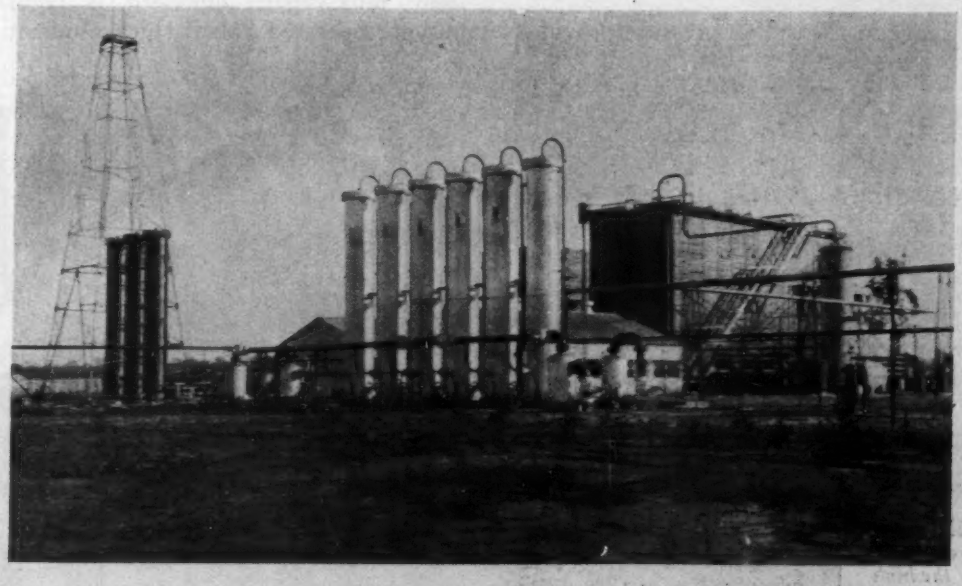
The gas is taken through six absorbers four feet in diameter and 30 feet in height. Because of the extreme high operating pressure it proved good practice to employ seamless hammer-welded shells with flat bolted heads at the top. Although this type of fabrication is costly, it permits the use of only six four-foot absorbers instead of 10 three-foot size, which would have been required with riveted shells, thus showing a considerable saving for the complete absorber installation. The heads of the absorbers are flat steel discs 5½ inches thick, secured to the top flange of the absorbers by 32 2½-inch diameter alloy steel bolts. The absorber shells are made of 1½-inch plate.

WEATHERING SYSTEM

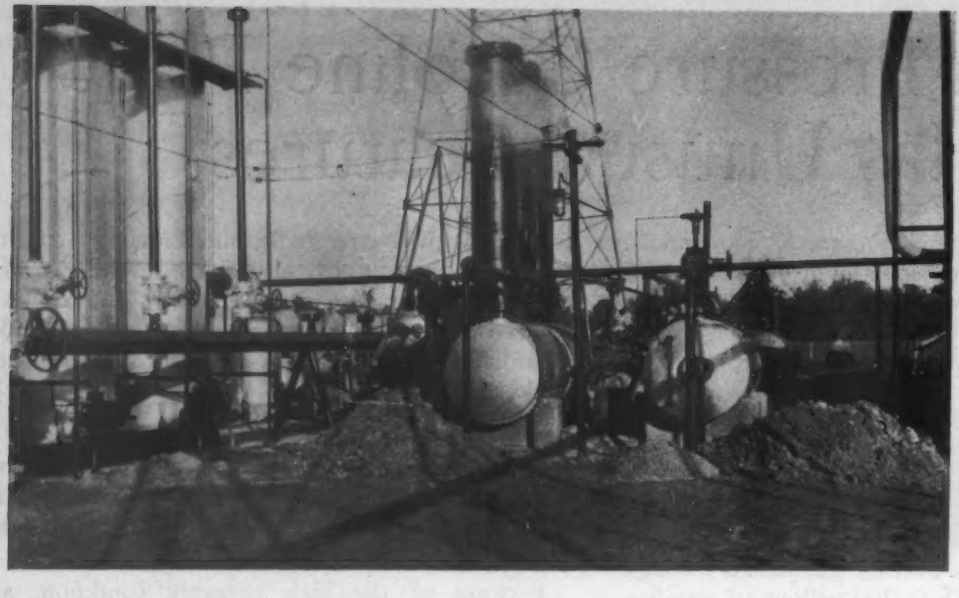
The outflow of oil from the absorbers is controlled by external balanced valves, which are operated by equalized floats working inside the base of the absorber shells.

Because of the high pressure condition, a large amount of fixed gas is dissolved in the oil leaving the absorbers. As all of the gas leaving the plant is being sold, it became necessary to provide compressors sufficient to put all fixed gases from the plant back to line pressure. In order to do this economically a two-stage weathering system was installed. The saturated oil leaving the absorbers through the outlet valves enters a large header which leads to a high pressure weathering tank. The oil level in this tank is held constant by means of a float control on its outlet, and the pressure is also maintained constant through the use of a back pressure regulator. Under present operating conditions the regulator is set to maintain a pressure of 190 pounds per square inch.

Saturated oil leaving the high pressure weathering device is conducted directly to a low pressure weathering tank, in which the oil level is held constant by means of a float controlling the steam to the fat oil pump, and the pressure is held constant by means of a back pressure regulator set for 30 pounds per square inch. The uncondensed vapor from the gasoline condenser



Louisiana Gas & Fuel Company absorption natural gasoline plant designed to operate at pressures ranging from 300 to 600 pounds per square inch. Additional equipment is shown going in to increase capacity to 150,000,000 cubic feet per day



Dual system of weathering which includes a high pressure weathering tank operating at 150 to 240 lbs. and a low pressure weathering tank working at 30 pounds pressure

flows under its own pressure into the vapor space in this weathering tank.

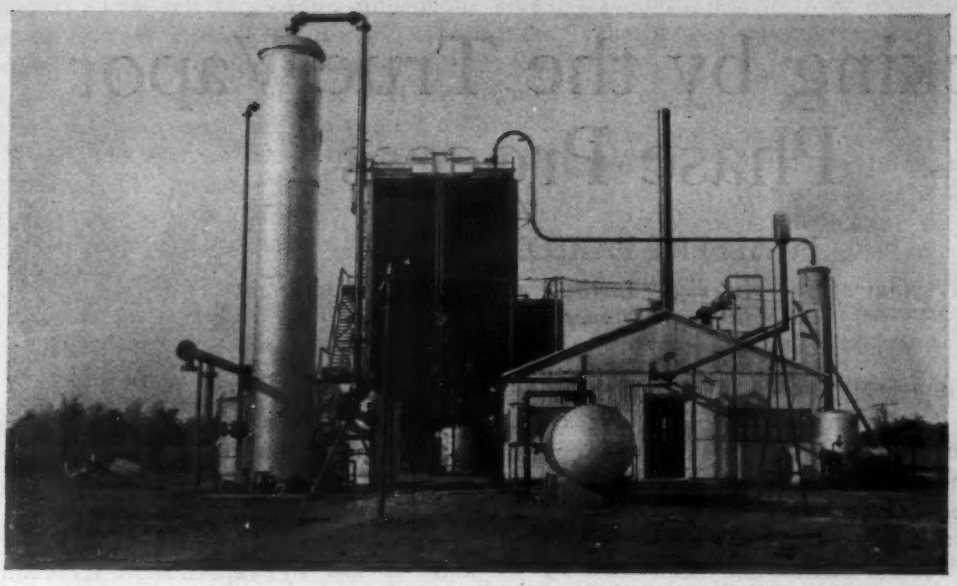
The pressure held in the high pressure weathering tank is selected so that about half of the total fixed gases in the oil are liberated in this tank, the balance of such gases being freed partly by the reduction in pressure in the low pressure tank and partly in the distillation system through the return from the condenser.

The weathered gas is recompressed through two Clark Brothers 180-horsepower direct connected gas engine driven compressors with two-stage compressor cylinders. A third unit is provided for stand-by service. The low pressure cylinders take suction from the discharge side of the back pressure regulator (Wilgus type) on the low pressure weathering tank. Gasoline recovered through compression and cooling mixes with the absorber oil in the tank and passes on into the distillation system. Also, the high pressure cylinders on the compressors take suction from the discharge side of the Wilgus back pressure regulator on the high pressure weathering tank, discharging the gas through cooling sections into the main line either behind or ahead of the absorbers.

Because of the range in absorption pressure provided for—600 to 300 pounds per square inch—the pressure maintained in the high pressure weathering tank must be varied from a minimum of 150 pounds to a maximum of 240 pounds per square inch, in order to preserve a proper division of load between the low and high pressure compression cylinders. In order to accommodate this range in suction pressure, the high pressure cylinders on the compressors are provided with variable clearance pockets which may be cut into or out of service to suit conditions. This system of two-stage weathering permits more than half of the total fixed gases to be recompressed from a high suction pressure, thus making a marked saving in the amount of power required.

Gasoline is stored in horizontal storage tanks at 10 pounds pressure. Vapors liberated in these tanks are taken through a header line through a back pressure regulator to the suction of a small steam driven compressor, which boosts them to the low pressure weathering tank, from which device they are compressed and handled as described above. The steam supply to the small tank-vapor-compressor is regulated by a diaphragm operated valve which automatically varies the

Natural gas from the field is brought into the plant through this measuring station through six six-inch lines at the high field pressure. Recording orifice meters are shielded by the metal building



High pressure plant of International Gas Products Company, similar in type to Louisiana Gas & Fuel Corporation plant as described in this article, but designed to handle 30,000,000 feet of gas through one absorber at about 185 pounds pressure

speed of the compressor so that it takes away vapors as fast as they are formed in the storage tanks.

ABSORPTION SYSTEM

Other than these special features just described, the plant was erected according to standard Campbell practice. Saturated oil leaving the low pressure weathering tank passes through the heat exchangers and steam preheaters to the vertical still which operates at 30 to 35 pounds pressure. The preheater units are mounted on elevated supports sufficiently high to return the condensed steam direct to the boilers without pumping. Agitation steam for the evaporator (still) is supplied by the exhaust from low pressure oil pumps and water circulating pumps.

Hot oil leaving the evaporator passes through an insulated horizontal surge or make-up tank and then through heat exchangers to the low pressure lean oil pump, under its own pressure. The pump forces the oil through the open type oil cooling sections mounted in the cooling tower, thence to the suction of the high pressure lean oil pumps, which discharge into the absorber oil inlet header.

Vapor and steam leaving the top of the evaporator pass to the dephlegmator at the top of the cooling tower. Gasoline leaving the dephlegmator is separated from any condensed water and reflux oil by a centrifugal screening type of mist extractor. The mixed oil and water flows down to the reflux dewatering tank where it is automatically separated from the reflux oil, which latter is returned by gravity to the reflux section in the top of the still. The gasoline vapor is taken to condenser section, from which the gasoline and uncondensed vapors pass into a gasoline dewatering tank. This tank is provided with two floats, one of which automatically drains off the accumulating water, and the other controls the outflow of gasoline to storage. Uncondensed vapors pass from this tank to the low pressure weathering tank, as previously mentioned.

The cooling tower is 22 feet wide by 88 feet long and 42 feet high. The walls are narrow louvre type, the interior being entirely open, no decks being used. Water is supplied through downward-directed spray nozzles carried on adjustable headers at the top of the tower, an auxiliary set of sprays being provided half way down the tower for use during extreme cold weather. Open type cooling and condensing sections are mounted on short supports above the surface of the water in the basin.

Two two-inch lines are provided from the gasoline plant to the loading rack at Archibald, five and one-half miles away. One of these lines handles gasoline from the plant and the other is used to transport absorber oil from cars to storage at the plant. For a considerable distance these lines are carried on supports to keep them out of swamp waters at low points. Welded joints are used throughout and the completed lines tested air tight at 450 pounds test pressure.

Equipment at the loading rack consists of a six-spot rack, two 27,000-gallon storage tanks, a small motor-driven triplex pump for pumping absorber oil to the plant, and a compression vapor recovery plant for recovering gasoline from vapors released during car loading, as well as from vapors from the two gasoline tanks.

The rack is of heavy timbered construction and provided with counter-balanced drawbridges at each spot. Two swing pipes with three-inch hose attached are provided at each spot, one being for loading and the other for conveying vapors to the recovery plant during loading. Gasoline flows from storage to cars under its own pressure.

Vapors produced while loading, and vapors from the storage tanks, are conducted through back pressure regulators to the suction of a belted motor-driven gas compressor which compresses the vapors to about 100 pounds pressure. The compressed vapors are cooled in an open cooling section in a small spray cooling tower which is supplied with cooling water by means of a small motor-driven centrifugal pump. Condensed gasoline is separated from uncondensable vapor in an accumulator with float control on the liquid. The uncondensed gases are allowed to blow to the air. Practically all of the vapors are recovered in this manner, and vapors wasted to the air are practically free of desirable gasoline fractions. Under summer conditions the recovery system saves about 300 gallons of gasoline per car loaded, and in addition, eliminates a very serious fire hazard.

Cracking by the True Vapor Phase Process

By ALBERT PARSONS SACHS

Fellow of the American Institute of Chemists, Consultant Chemical Engineer, New York

EVERY process that represents a distinct advance in the art of which it is a part has behind it a history full of human interest. Such a story of the adventures of a technological idea on its path of fulfillment and acceptance is quite as thrilling as any tale of individual human success. The development of the True Vapor Phase Process, owned and licensed by the Petroleum Conversion Corporation, is a case in point. For the purpose of this article, however, the human interest element will be laid aside and only the strictly scientific and engineering features considered.

The fundamental theoretical importance of cracking in the vapor phase is so great that it will not be out of place to recall the principles on which it is based.

While other factors are involved, the chief factor in cracking is temperature. For a moment let us consider cracking from the point of view of temperature in a rather special sense.

Matter exists in three states, solid, liquid and gaseous. In cracking we are never concerned with the solid state (except in the case of carbon deposits, of which more anon), because practically all materials used as cracking stock are liquid at ordinary temperatures and pressures, and are either liquid or gaseous at the temperatures and under the conditions of cracking.

Cracking is said to occur in either the liquid phase or the vapor phase, the expression "vapor phase" being identical in this case with "gaseous phase." It will be pointed out later that the distinction between liquid phase and vapor phase as applied to cracking is not quite scientifically correct, but it is sufficiently so for ordinary purposes.

VAPORIZATION

Boiling is a special form of vaporization. When the vapor pressure of a liquid equals or exceeds that of the external pressure imposed upon it (the atmosphere, for example) then bubbles of vapor can and do form in the body of the liquid. Boiling is a phenomenon which depends on the external pressure of the system. Boiling is bubbling.

Water vaporizes at all temperatures, but it boils at 212°F. when the external pressure is one atmosphere (14.69 pounds per square inch). If the external pressure is raised the boiling point is raised, so that under a pressure of 100 pounds per square inch the boiling point of water is 350°F., but the vapor pressure of water remains 14.69 pounds per square inch at 212°F. regardless of what the external pressure may be. At every temperature vaporization will occur (regardless of whether boiling can occur) until the space above the liquid is saturated with the vapor of that liquid.

A mixture of substances like the mixture of hydrocarbons found in any cracking stock supplied to a cracking apparatus has no truly definite vapor pressure at each temperature, nor has it a definite boiling point. If a sample of gas oil is exposed to the atmosphere it very slowly evaporates or vaporizes. As part of its mass is lost by vaporization its composition changes and its vapor pressure changes. The boiling point at a given external pressure is, in general, higher than the boiling point of the constituent with the lowest boiling point and lower than the boiling point of the constituent with the highest boiling point.

Now we are prepared to discuss what happens in the matter of phases in ordinary cracking processes.

CRACKING PHASES

Suppose we desire to crack a given charging stock at 890°F. because we have decided that at 890°F the type of cracking which occurs with that charging stock is the kind we want. Let us assume the simplest case, that represented by the earliest type of Burton still. We have a large kettle or still which we heat externally by a flame. The charging stock is, let us say, a reduced crude. Let us say that we have so stripped it of its lighter constituents that the initial boiling point (without attempting to define "initial boiling point") is 500°F. This means that the vapor pressure of this mixture, a reduced crude, is 14.69 pounds per square inch at 500°F., and increases as the temperature rises. If the still is open to the atmosphere the prevailing pressure is 14.69 pounds per square inch, and if the temperature reaches or rises above 500°F. the charging stock will boil and large amounts of vapor will form and, unless means are taken to prevent it, the vapor will pass out into the atmosphere or into a condenser. As temperature rises considerable portions of the charging stock will have been vaporized at temperatures below 890°F. at which the desired type of cracking occurs. This removal of material from the system below the temperature at which cracking occurs is, of course, undesirable.

To overcome this undesirable state of affairs we have two courses open to us, namely, to take this vapor and heat it separately to the predetermined cracking temperature of 890°F., which would constitute vapor phase cracking, or to arrange our cracking system so as to prevent escape of vapor from it. In the latter case it is necessary to limit the volume of the vapor space above the oil; as the temperature of the liquid oil rises its vapor pressure rises, and because of the limited space above the oil the pressure within the entire sys-

tem increases. This self-formed or autogenous pressure acts to prevent further boiling or vaporization which can occur only by further application of heat and further rise in temperature. Of course, if the volume of the apparatus were large and the volume of the oil small it is possible that all the oil might vaporize in spite of the increased pressure. But cracking still design and operation are such that the space above the hot oil is kept small in proportion to the volume of the liquid.

At the cracking temperature both oil and vapor will exist under these conditions. It is impossible to prevent all formation of vapor, but design may be arranged so as to limit the amount of vapor formed. If cracking occurs when any liquid is present we have liquid phase cracking so-called, although, as a matter of fact, in all liquid phase cracking we have both liquid and vapor present.

In true vapor phase cracking we must have absolutely no liquid present. The presence of any liquid whatsoever makes the process a liquid phase process. This is no mere quibble about definitions; there is a fundamental difference between vapor phase cracking and liquid phase cracking as defined above.

VAPOR CONDITION

At the highest temperatures reached in cracking practice there is a considerable possibility that we have reached or passed the critical point. As the temperature and pressure of a liquid phase and a vapor phase co-existing in a closed system rise we have the following phenomena occurring. At higher temperatures the oil becomes lighter and more fluid while at the higher pressures corresponding to the increased temperature the vapor becomes more dense and viscous. Finally a temperature and pressure is reached at which the thinner liquid and the denser vapor acquire the identical density. Above this temperature there is no difference between liquid and vapor and the system has the properties of a vapor. The temperature and pressure for which this phenomenon occurs for a liquid consisting of one pure component is known as the critical point. It is thought by many that at the temperatures used in high pressure "liquid phase" cracking the critical point has been reached and passed and that all the charge is in the form of vapor under the pressure which prevails in the system. However, our knowledge of the nature of critical phenomena in the case of the extremely complex mixtures existing in a cracking system is very limited. It is certain that the type of cracking which occurs in the highest pressure commercial cracking systems is distinctly different from that which occurs in vapor phase systems.

Let us assume that we have not created any considerable autogenous pressure but have allowed vapor comparatively freely to form. This vapor may now be conducted to a suitable heating vessel and there raised to the desired cracking temperature. This would constitute vapor phase cracking. It is to be noted that vapor phase cracking can be conducted at any temperature at which cracking occurs, without the impression of any external pressure. It may be conducted at atmospheric pressure or under vacuum or under moderate pressures. Liquid phase cracking demands high pressures to reach the desired cracking temperatures.

We have this to bear in mind, that in liquid phase cracking the selection of a given cracking temperature necessitates the use of a certain pressure or relatively narrow range of pressures, and that in vapor phase cracking any pressure can be used for a given temperature. That is to say, any pressure less than a certain value which would cause some reliquefaction to occur. Thus vapor phase cracking must be conducted at lower pressures than liquid phase cracking and may be conducted at any lower pressure.

The process which uses liquid phase cracking is committed to a definite pressure when it selects its temperature for a given charging stock. It is known that a lower pressure is advantageous from an engineering point of view and from the point of view of safety, but the process is committed to the high pressure necessary to maintain at least a considerable part of the charging stock in liquid form.

The process which uses vapor phase cracking can select the temperature deemed best for cracking and can then independently fix upon the pressure deemed desirable for engineering or other reasons.

If the resultant freedom of choice in the matter of pressures were the whole of the problem there would be no question whatsoever that the vapor phase processes would be the only ones in use. Although the theoretical advantages of vapor phase cracking were recognized by the earliest workers in the field, other features, chiefly of an engineering nature, have made the decision doubtful. As a matter of fact until quite recently the liquid phase processes have held the field almost exclusively.

Information Circular 6127 of the Bureau of Mines, issued May, 1929, states (page 2): "The general desire on the part of motorists for gasoline of high anti-knock qualities is reported to have given impetus to the active development of the vapor phase system of cracking. This would seem to be substantiated by this survey which lists . . . 18,700 barrels capacity on January 1, 1929, as compared with . . . 6,100 barrels on January 1, 1928." But the total capacity (erected and under construction) of cracking plants in the United States on January 1, 1929, was 1,476,874 barrels, so that vapor phase capacity was hardly more than one per cent of the total.

Now then, what has been the difficulty? It would be tedious to quote the various writers who have pointed out the inherent theoretical advantages of vapor phase cracking and the practical engineering difficulties. We may summarize their opinions.

VAPOR PHASE DIFFICULTIES

But first let us anticipate. The chief difficulties, as we shall point out later, of conducting vapor phase cracking have all had their origin in the assumption, which we shall show to have been quite naive, that in vapor phase cracking the oil vapor must be heated in stills or tubes from the outside exactly as liquid oil must be heated. The True Vapor Phase Process does not heat the oil vapor in externally heated stills or tubes,

but uses a totally different method and thus avoids all those difficulties which the experts have declared to be inherent in vapor phase cracking.

The summary of the difficulties in the way of successfully achieving vapor phase cracking as formerly assumed are:

(1) The lower density of oil vapor as compared to oil liquid leads to lower rates of heat transfer and thus to larger heat transfer surfaces for a given transfer of heat;

(2) To overcome the difficulties of (1) higher temperatures are required and these lead to rapid destruction of equipment;

(3) Owing to the higher temperatures, decomposition into carbon and hydrogen is much more common, and the deposition of carbon on the heat transfer surfaces leads to hot-spots (owing to the low rate of thermal conductivity of carbon) and the ultimate burning through of the metal);

(4) The once through rate of conversion is poor unless really high temperatures are used, in which case excessive formation of carbon and permanent gas occur.

A disadvantage (5) may be mentioned which most writers have completely neglected. This is that iron catalyses the decomposition of hydrocarbons into carbon and hydrogen; vapor phase cracking as conceived by them involves large iron surfaces and high temperatures, both of which cumulatively favor the undesirable catalytic production of carbon and hydrogen.

Furthermore, the type of gasoline produced by the higher temperatures used in vapor phase cracking was formerly considered undesirable and difficult to refine. Owing to the recent proper understanding of the nature of knocking and its relationship to composition of the motor fuel, it is now freely and unanimously agreed that vapor phase gasoline is a most desirable type of motor fuel; refining difficulties have been overcome by means so simple and inexpensive that it is altogether probable that the refiners of straight run gasoline and of liquid phase cracked gasoline will learn something of advantage from the processes applied to vapor phase cracked gasoline.

TRUE VAPOR PHASE PROCESS

Now then, we may turn our attention to the principles on which the True Vapor Phase Process has been developed and discuss how it avoids the disadvantages previously cited and incidentally gains other advantages such as complete freedom from corrosion and the elimination of pressure hazard.

Oil vapor is produced in standard vaporizers below the cracking temperature. No matter how heavy a residuum is being used as the cracking stock the vaporizer receives only overhead distillate as a result of preliminary treatment within the process itself. Because of the moderate temperatures used in the vaporizers and the exclusive use of overhead distillate, no trouble whatsoever is met with in the vaporizers, regardless of the type of charging stock supplied to the system. This vapor is separated from liquid by flashing into a suitable flash tank and is then moderately raised in temperature to superheat or dry it, but still below the cracking temperature. This dry vapor is then led to the cracking or reaction chamber.

Instead of attempting to heat this dry vapor in tubes with the disadvantages previously mentioned and recognized by the industry at large, it is merely mixed with the correct amount of a hot inert gas which gives the desired temperature instantly to the mixture. No hot tubes, no over-heating, just the flow of a hot gas and of oil vapor through a stationary mixing device.

Since the mixture of oil vapor and inert gas is at the proper temperature in the reaction chamber it is not necessary to supply additional heat to the mixture. Therefore, the reaction chamber is heavily insulated by fire-brick and other refractory thermal insulating materials internally. The reaction chamber exposes absolutely no iron to the cracking mixture and the harmful decomposition into carbon and hydrogen does not occur. The five disadvantages of vapor phase cracking disappear.

We must, of course, be assured that the inert gas can be obtained and heated economically. The inert gas used is the gas produced in the course of cracking after it has been stripped of all its valuable constituents by absorption. The heating of the inert gas is not carried out in a tubular heater which we have seen is uneconomical as a gas heater. The heating system is the hot blast stove of the iron industry.

BLAST STOVE

In blast furnace operation it is necessary to supply to the blast furnace vast quantities of preheated air. Since air was first preheated for blast furnaces a century ago, the iron industry has developed a remarkably efficient, rugged and simple type of heating device, the hot blast stove, which provides the hot blast for the blast furnace and hot inert gas for the reaction chamber of the True Vapor Phase Process.

The hot blast stove is essentially a huge cylinder built of steel sheets and heavily insulated internally with fire-brick and other refractory insulating materials. The interior is filled with a brick checkerwork in addition to a combustion chamber. Fuel, gaseous or liquid, is burned in the combustion chamber and the hot gases pass through the checkerwork (generally upward through the combustion chamber which extends to the dome of the stove and then annularly downward through the full length of the checkerwork) to a stack. Owing to the long path of travel of the combustion gases the stack temperature can be reduced to any reasonably desirable figure.

When the checkerwork has been sufficiently heated combustion is stopped and the inert gas to be heated is passed over the checkerwork to remove from it the heat stored in it.

The hot blast stove is the most efficient heat transfer unit known. More than 80 per cent of the theoretical heat of combustion of the fuel used can be delivered to the inert gas.

The inert gas may contain some methane and ethane which may decompose into hydrogen and carbon partially in the stove. At this point the decomposition is absolutely harmless as the carbon insulates no heat transfer surfaces and the hydrogen remains as a constituent of the inert gas. Furthermore, on the next reversal to combustion the carbon is burned out.

The reaction chamber is designed to allow the time necessary for the maximum or for the optimum once through conversion at the temperature selected. A

rough figure for the cracking temperature would be about 1000°F. Pressure is unnecessary as such, and only such a moderate pressure, about 50 pounds, is used as is found desirable in the interests of good circulation, to overcome friction, etc, and to limit the volumes handled.

VAPOR PROCESSING

The products of cracking as they leave the reaction chamber consist of a mixture of gases without any liquid whatsoever. The oil vapor entered the reaction chamber as an absolutely dry vapor; the admixture of a much larger volume of the hot and much less dense inert gas instantly lowers the partial pressures of the oil vapors (the same volume of oil vapor is diluted to a much larger volume of mixture and the concentration of oil vapor per unit of volume becomes less; concentration per unit of volume of a vapor or gas and partial pressure are synonymous) so that they cannot condense even if cooled considerably. In addition a considerable portion of the oil vapors have been cracked to lighter hydrocarbons.

As the products of the cracking operation leave the reaction chamber they enter the bottom of a scrubber-rectifier at the top of which enters the preheated cracking stock.

This cracking stock may, for example, be a crude containing straight run gasoline or a topped crude or a heavy fuel oil or gas oil or other distillate. There is heat exchange by direct contact between the products of cracking and the charging stock. There is a complete blending of all constituents and components of the total mixture. The bottoms from this scrubber-rectifier are the heaviest fractions of the charging stock and any heavy fractions that may have formed by polymerization during the cracking reaction. Owing to the high temperatures prevailing in this scrubber-rectifier, viscosity cracking of the heavy residuum of the crude oil or fuel oil occurs and the bottoms are, therefore, ordinarily a low viscosity fuel oil. The gravity of the fuel oil produced can be controlled at will by means of a reflux pump which carries back part of the bottom from the scrubber-rectifier to the top through standard heat exchangers.

The overhead from the scrubber-rectifier contains all the inert gases together with the gas produced by cracking, all the cracked gasoline (together with any straight run gasoline which the charging stock may have contained), kerosene, gas oil and recycle stock. It may be noted here that under the conditions prevailing in the scrubber-rectifier a deeper cut is made into the crude than is possible by direct distillation at the same temperature. Owing to the presence of the large volume (volume, not weight, counts in this relationship) of inert gas the partial pressure of each component is reduced so that the crude is actually being distilled at less than atmospheric pressure, although the system pressure is higher than atmospheric. The total pressure is higher than atmospheric so that ordinary boiling cannot occur, at least for the higher boiling constituents, but the partial pressure of the constituents is so low that rapid vaporization occurs, aided by the sweeping out effect of the large volume of gases. It has been possible to cut so deep into asphalt-base crudes that the bottoms withdrawn from the scrubber-rectifier solidified when they had cooled only to a moderate extent.

RECTIFICATION

The overhead is passed through rectifiers which separate out first everything boiling higher than gasoline. This condensate is the vaporizer charging stock. Regardless of the type of material to be cracked the vaporizer receives only this clean overhead.

Owing to the partial pressure conditions prevailing, the vaporizer stock condenses out at lower temperatures than would be expected if this factor were not taken into account. This is in itself no advantage or disadvantage, and is mentioned only to bring out the difference between operating conditions in the True Vapor Phase Process and other processes.

The gasoline cannot be condensed completely by water condensers alone, but the condensers must be followed by absorption to remove the lightest ends from the inert gas.

After stripping is complete, the excess of gas is bled to a gas holder and the amount necessary for operation passes back through heat exchangers, picking up low temperature heat on its way to the hot blast stoves to be reheated. The inert gas is thus cycle gas.

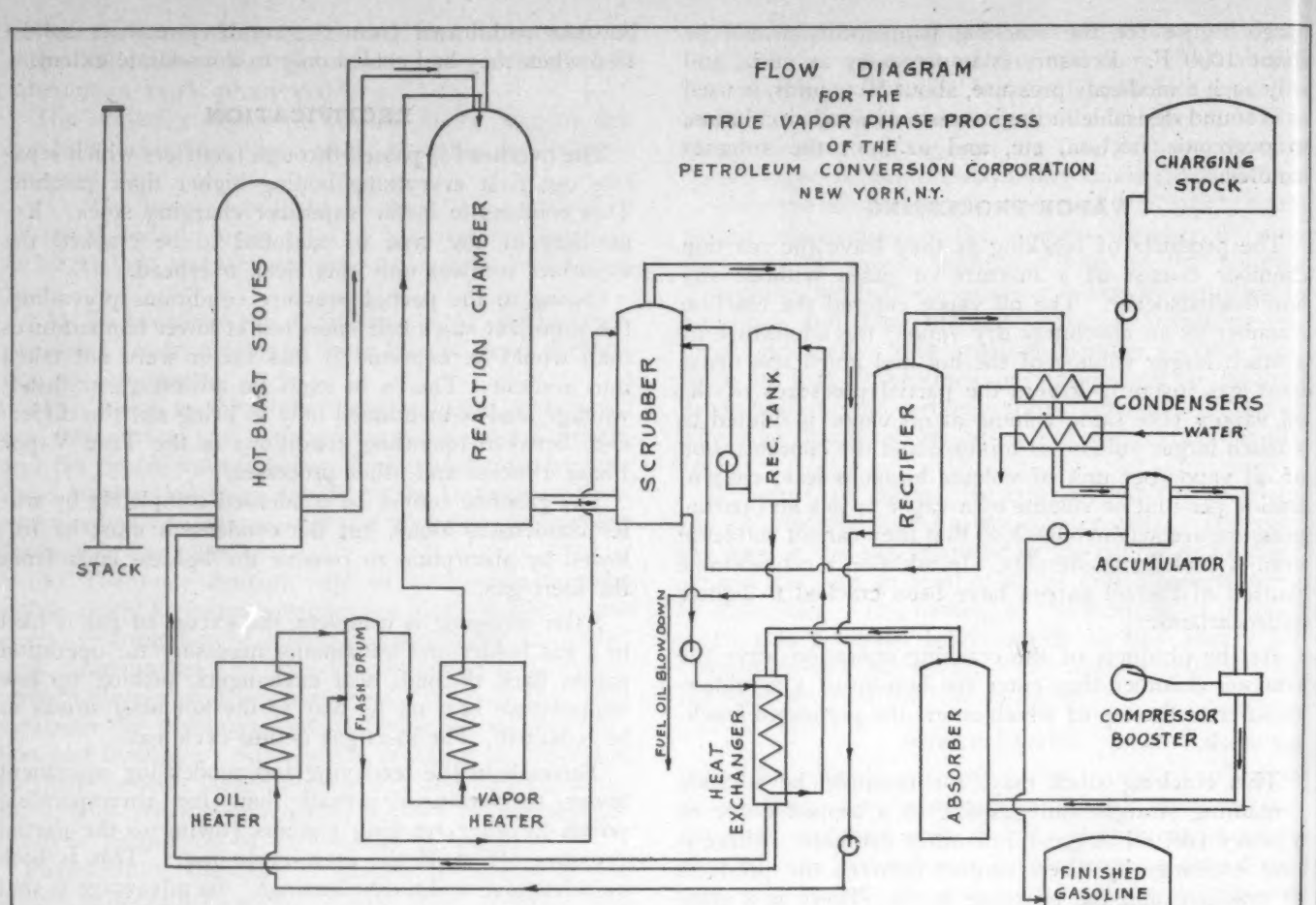
Throughout the rectifying and condensing equipment lower temperatures prevail than for corresponding points in other cracking systems (owing to the partial pressure effect of the inert cycle gas). This is both an advantage and a disadvantage. Its advantage is that heat exchange operations and heat recovery can be carried downward to lower temperatures, and that the equipment meets less arduous duty; the disadvantage is the increased absorption capacity necessary.

GASOLINE NOT ACID TREATED

Refining of the total gasoline distillate (the condensate and the lighter fraction obtained by absorption and stripping) is carried on at the Texas City plant of the Petroleum Conversion Corporation by a special contact process without the use of any acid. The product is completely satisfactory from the point of view of color, color stability, gum content and potential gum content.

The straight cracked product is in general equal or superior to pure benzene in anti-knock value. In the Ricardo variable compression engine pre-ignition occurs with this gasoline before knocking begins, exactly as with benzene, and at approximately the same or higher compression ratios as pre-ignition occurs with benzene. For blending purposes its superior to pure benzene.

In view of the brick lining of the cracking chambers and of the scrubber-rectifier it need hardly be said that corrosion does not occur even with the most highly sulphur-bearing stocks (California, West Texas, etc.). Beyond the scrubber-rectifier the prevailing temperatures are below those necessary for active corrosion by sulphur; in addition there is the circumstance of dilution caused by the inert gas. Pressure, concentration and temperature are the factors which favor corrosion by corrosive petroleum products. In the True Vapor Phase Process wherever brick linings do not completely prevent corrosion, low pressure, low temperature and great



dilution with inert gases practically prevent corrosion.

This process, therefore, produces vapor phase motor fuel of the highest anti-knock value known, in a simple system which completely avoids the hazards due to pressure and corrosion; by the use of a principle of heating basically new to the petroleum industry it avoids over-heating and its resultant gas and carbon production. By the elimination of iron in all the hot parts of the system the detrimental catalytic effect of this material is completely avoided. Carbon production is negligible and no provision need be made for its removal. The plant operates continuously.

TABLE 1

Charging Stock—West Texas Residuum

Tests on the Charge

Gravity, 20.0 A.P.I.	Distillation		
Color, Black	I.B.P.	370°F.	
Flash Point (O.C.) 235°F.	5%	486	
Fire Point, 295°F.	10%	556	
Viscosity at 210° 66 seconds	20%	620	
Sulphur, 3%	32.5%	672	(Cracking)

Vaporiser Charge	Gravity	11.9	A.P.I.
	Viscosity at 100	45	seconds
	I.B.P.	500°F.	
	10%	536	
	20%	564	
	30%	584	
	40%	610	
	50%	644	
	60%	668	
	70%	708	
	70%	724	(Cracking)

FLOW CHART

The accompanying diagram gives an idea of the arrangement of equipment in a plant of this type, such as is being erected by the Western Oil & Refining Company at Wilmington, California, (Los Angeles Harbor) and by the Shell Petroleum Corporation at its Wood River, Illinois, refinery. Each of these units has a capacity of more than 2000 barrels of finished cracked gasoline per day. When crude is used as charging stock the output of finished blended gasoline may reach 4000 barrels of finished gasoline per day per unit.

The following is an example of the results obtained with this vapor phase process. It is not selected as the best, but merely as a random example. Note that although only 32.5 per cent of the charging stock distills to 672°F., a much larger fraction than 32.5 per cent is actually distilled out of this material and delivered as overhead to the vaporizer as shown by the gasoline yield figures. Further, it is seen that the actual vaporizer charge when distilled at atmospheric pressure has a high initial boiling point and that only 70 per cent distills over in the laboratory distillation at 724°F. The charging stock used in this run had a high asphaltic content. In other processes this would have led to immediate coking of the stills. In this system it was removed continuously as liquid (suitable for further treatment to asphalt if desired) which solidified upon cooling.

(*Continued on page* 79)

Factors Affecting the Determination Of Gum in Gasoline

By C. R. WAGNER* and JULIUS HYMAN†

Paper delivered at Tenth Annual Meeting, American Petroleum Institute, Chicago, Illinois, December 5, 1929

ONE of the more important problems which confront the producers of cracked gasolines is that of gum formation. Such gasolines, if improperly refined, or if allowed to stand for long periods in contact with the atmosphere, seriously affect the operation of certain types of gasoline motors. These motors, upon investigation, show the intake valves stuck tightly and the guides clogged with a black, brittle, carbonized deposit. One speaks in such cases of the "gumming" effect of the gasoline. The analytical determination of the gum content of gasoline has for years been a controversial matter. The authors have been led to present the results of their work in the hope that they may be able to assist somewhat in clearing up the existing confusion among oil testing laboratories on this subject.

A sample of such gasoline as described just previously, when evaporated on the steam bath, leaves behind a deposit which may vary in color from a very pale amber to a brown-black, and in consistency from a brittle solid to a sticky, viscous resin. The type of gum usually met with is reddish-brown and solid—although, as the gum content in gasoline increases, the gum tends to assume a somewhat lighter color and less solid consistency. The odor of the gum resembles closely that of varnish.

Once gum has been formed from gasoline, it is dedissolved in it only to a comparatively slight extent. This statement may quickly be verified by dissolving 0.05 g. of gum in 1 cc. of absolute alcohol. To this concentrated solution add 20 cc. of a fresh sample of a highly cracked gasoline, and shake immediately. After shaking, it will be noticed that most of the gum has reappeared as a floculent precipitate. On the other hand, it is not at all unusual for a 20 cc. sample of an old cracked gasoline to show 0.05 g. of gum when evaporated on the water bath or in the steam oven. Benzene acts as a somewhat better solvent, but the best solvents appear to be the ethers, alcohols, and lower organic acids. Thus, commercial ethyl alcohol dissolves gum completely.

When dissolved in alcohol or any other solvent, the color of the gum persists in the solution. This observation is of especial interest, in view of the common belief among the uninitiated that the color of a gasoline bears a direct relation to its gum content. There is no foundation in fact for this widespread notion, which seems to have sprung up with the development of liquid phase cracking processes. Decidedly yellow gasolines, for example, often show very little gum, whereas water-white samples may show great quantities.

Another misapprehension regarding gum is the terming thus of material which separates out when unsaturated gasolines are allowed to stand exposed to light and air for long periods of time. Such material appears actually to be made up of layers—a less dense, light colored, oily layer and a heavier, deep colored, viscous resin. While it is quite likely that some true gum is dissolved in both of these layers, other materials—notably peroxides—are also present. Thus, both oily and viscous layers react with an hydriodic acid solution to produce iodine; whereas this reaction does not occur with either the solid or viscous gums formed by evaporation, even though the gums have previously been dissolved and the solutions heated. Furthermore, the oily layer appears to explode when heated, a phenomenon which does not occur with true gum.

We seem, then, to be faced by a condition which has been overlooked quite generally, viz., that so-called "gummy" gasoline contains actually little or no gum in the sense of the word as applied to resins left by evaporation. The harmful constituents in old unsaturated gasoline seem, rather, to be the gum forming materials. For the sake of clarity and brevity, we shall hereafter refer to these gum forming materials as the "pseudo-gums" as differentiated from "residual gums," viz., the resin remaining after the gasoline has been completely driven off by heat. We feel that thus a considerable amount of misunderstanding which now exists on the subject may be overcome. For example, in their excellent paper,[1], [a] Voorhees and Eisinger showed that "gumming trouble in automobile operation was traceable directly to the amount of pseudo-gum in the gasoline. Unfortunately, they use the term "preformed gum," which appellation assumes the presence of the actual gum itself.

Gum research and control must hinge upon a reliable quantitative method of pseudo-gum determination. Thus far no absolutely satisfactory method has to our knowledge been evolved. The best to date, we feel, is that of Smith and Cooke[2]. These investigators suggest the evaporation, in a steam oven, of a 20 cc. gasoline sample contained in a special pyrex glass evaporating dish of 30 cc. capacity. The one disadvantage of this method for routine work is the somewhat troublesome use of the steam oven. For this reason we have modified the Smith and Cooke method by evaporating the samples on an actively boiling water bath, a very simple procedure.

The method finally arrived at is briefly as follows: 20 cc. of the gasoline to be tested is pipetted into a clean, weighed 30 cc. pyrex glass dish (50 to 52 mm. wide by 21 mm. to 23 mm. deep), which is then placed

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†Research Chemist, The Pure Oil Co.
[a] Numbered references refer to bibliography at end of this paper.
[1] Ninth Annual Meeting, Amer. Pet. Inst., Chicago, Dec. 7, 1928.
[2] Bur. Mines Report No. 2394 (1922); No. 2586 (1925.)

on an actively boiling water bath so that the deepest possible immersion of the dish is obtained. There is no objection to the escape of steam around the edge of the dish, but water should not collect in the dish. After evaporation of the sample, the bottom of the dish is wiped free of water (and dirt from the bath cover); the dish is placed in an oven at 105 degrees C. for 30 minutes; then set in a dessicator to cool, and finally weighed. The increase in weight is reported as grams gum per 20 cc. of gasoline.

Water bath results, however, are always higher than steam oven results, due evidently to the oxidation which takes place in the gasoline on the water bath. So long as the pseudo-gum content is low, the numerical differences in the two methods are not great. If the pseudo-gum content is high, however, or if the gasoline sample to be evaporated is large (as it is in the copper dish test), then the gum formed by the water bath method is very much greater than the gum produced by the steam oven method. Table I is typical:

TABLE I

Method	Sample No. 1	No. 2	No. 3	No. 4
	Weight of Gum in Grams			
Steam oven (20 cc. sample)	0.0003	0.0033	0.0115	.....
Water bath (20 cc. sample)	0.0009	0.0190	0.0660	0.1205
Copper dish (100 cc. sample)	0.1930	.....	.....	0.7500

Here one sees at once the marked unreliability of the copper dish test for gum determination as prescribed in Method 530.1, Technical Paper 323-B of the U. S. Bureau of Mines. The discrepancy is especially noticeable where the pseudo-gum concentration is extremely low. On the other hand, tests in our laboratories show the water bath method to give from three to six times more gum than is formed by the steam oven method. These small multiples enable one to rely upon the water bath method as an index at least of the "gumming tendency" of gasolines, and at the same time allow the routine operators to weigh larger amounts of gums, thus reducing methodical errors. We have used with satisfactory results the water bath modification of the Smith and Cooke test as a routine gum determination method during the last three years.

It occurred to the authors that some definite relation might be found to exist between the mechanism of the pseudo-gum forming reaction and the ratio of the results of the water bath method to the results by the steam oven method. This ratio appears to be moderately constant, regardless of the quantity of residual gum found, although when very small amounts are present there are enough methodical errors in weighing to cause some variation in the ratio. More strangely, however, there is little difference in this ratio when great variations occur in the pseudo-gum forming tendency of various gasolines. In view of these facts, it seemed best to give serious consideration to the chemistry of residual gums and the mechanism of the reaction forming pseudo-gum.

Smith and Cooke ran a combustion analysis on residual gum, obtained—it would seem—from liquid phase cracked gasoline. We have run a combustion analysis on residual gum obtained from vapor phase cracked gasoline. The results are tabulated below (Table II.)

TABLE II

	Smith and Cooke	Our Data
Hydrogen, per cent	7.39	6.75	8.00
Carbon	69.48	70.62	73.59
Oxygen	19.93	21.06	17.17
Ash	2.78	1.00	...
Sulphur	0.28	0.50	1.24
Nitrogen	0.14	0.07	...

These data indicate the general similarity in the composition of residual gum, regardless of source; the empirical formula of the gums would be $(C_6H_8O)_x$. We further found an acid number of about 65 and a saponification value varying from about 250 to above 300, indicating either an ester or lactone structure for the gum. Upon heating over an open flame, residual gum gives off inflammable vapors possessing an oder reminiscent of burning rubber. The odor of the residual gum, when cold, is more or less ethereal.

If, however, gasoline containing pseudo-gum be shaken with water and the water extract evaporated on the water bath, there remains behind a brownish gummy material possessing an odor similar to that of caramel or which may smell like musty straw. Similar odors are observed when residual gum is taken up in a very little alcohol, the alcohol solution then poured into a small amount of water to form a colloidal suspension, which, after filtering to remove large particles, is evaporated on the water bath to a sticky gum. The indication in the first of these experiments points toward the direct formation of sugar and furan derivatives, while in the latter experiment the partial saponification of the esters or lactones into their acids and sugar or furan derivative alcohols is indicated. The gum formed in the first experiment dissolved in water to form a cloudy solution possessing a rather bitter and slightly sour taste. Alcohol also acted as a solvent, but ether dissolved only a small amount of the gum. With the gum formed in the latter experiment, the solubilities were reversed.

Another interesting point concerning residual gum is its tendency to lose weight upon being heated to temperatures slightly above 100 degrees C. For example, Table III shows the continued loss in weight during an afternoon of two representative samples of residual gum heated to 105 degrees C. in an electric oven.

TABLE III

Weight in Grams	
Sample No. 1	Sample No. 2
0.0266	0.0314
0.0241	0.0281
0.0204	0.0262
0.0184	0.0236
0.0178	0.0220

While the exact reason for this loss in weight has not been investigated, it appears probable that its cause is to be found in the splitting off of water from the gum complex, with the resultant formation of esters, lactones, or double bonds.

Smith and Cooke recognized the presence of aldehydes in old cracked gasolines. Brooks[3] verified this observation, but showed that the simpler aldehydes were incapable of forming residual gums. We have found, however, that when technical crotonaldehyde is dsisolved in a saturated straight run gasoline and exposed to the action of oxygen in the light, pseudo-gum forms very rapidly; and the residual gum formed from it possesses

[3] J. Ind. Eng. Chem., 18, 1198 (1926.)

odor, color, and solubility characteristics quite similar to the residual gum produced from old cracked gasolines. (See Table IV.) These facts give strong indication that the two gums are of similar origin.

TABLE IV

	Grams Residual Grams per 20 cc. Sample	
	Fresh	Old
5 per cent crotonaldehyde solution	0.0045	0.0428
10 per cent crotonaldehyde solution	0.0209	0.0836

It is interesting to observe the action of alcoholic potash on gasoline containing pseudo-gum. When a small amount of alcoholic potash solution is dropped into a diluted sample of such gasoline, a reddish-brown resin is formed, quite analogous to the action of alcoholic potash on diluted aldehydes. Preliminary work in this laboratory indicates that when this resin is dissolved in alcohol, the resulting depth of color of the solution is proportional to the residual gum value of the gasoline. When alcoholic potash is added to gasoline high in pseudo-gum, the reaction is almost explosive in violence. While this does not prove that aldehydes are the pseudo-gums, it does mean that the production of aldehydes runs hand in hand with the formation of pseudo-gums.

Enlightening on the mechanism of pseudo-gum formation is the action of oxygen on highly cracked gasoline free from pseudo-gum. Such gasoline, kept in the dark in a tightly stopped glass bottle and under an atmosphere of pure oxygen, appears to remain free from any great amount of pseudo-gum for quite a long period of time. Table V shows a representative run:

TABLE V

	Grams Residual Gum per 20 cc. Sample Gasoline
Start	0.0004
16	0.0004
36	0.0006
45	0.0010
110	0.0020

This stationary state in the oxidation of pseudo-gum-free unsaturated gasoline is the so-called "period of induction." Its existence is often explained on the assumption that an anti-catalyst is present in the gasoline which retards the oxidation until the anti-catalyst is completely used up. As a matter of fact, it is known that such materials as water have an inhibiting effect on certain auto-oxidations. In view of the very widespread character of this "phenomenon," however,[4] even with highly purified materials, we do not believe that the explanation of the "induction period" necessarily involves the assumption of an anti-catalyst. A much simpler explanation, at least in the case of cracked gasolines, appears to us to lie in the two following assumptions:

1. At ordinary temperatures and in the absence of catalysts or light, pure oxygen does not attack pure hydrocarbons.

2. Among the products of atmospheric oxidation of hydrocarbons are materials which catalyze further the atmospheric oxidation, i.e., the atmospheric oxidation of hyrodcarbons is an auto-catalytic reaction.

Thus, the "period of induction" may be interpreted as being the beginning of the auto-catalytic reaction, the measurement of the minute quantities of the reaction products falling within the limits of experimental error.

The first of these assumptions appears probable from results similar to those in Table V. The truth of the second assumption appears to have been tacitly accepted for some time. Although the existence of auto-catalysis is not so highly pronounced at room temperature (occasioned perhaps by the formation of some intermediate, fairly stable compound), the phenomenon is very evident at 100 degrees C. as has previously been described by Voorhees and Eisinger. We have run a parallel experiment, placing 100 cc. of fresh vapor phase gasoline in an old calorimetric bomb and filling the bomb with oxygen to 310 pounds pressure. A pressure gauge was fitted to the bomb, and the bomb immersed in boiling water. Table VI shows the rate of oxygen absorption:

TABLE VI

Time (min.)	Pressure (lb.)	Decrease
Start	310	..
10	270	40
20	220	50
30	160	60

The gasoline thus oxidized smelled strongly of acrolein, and the gallic acid test (Mulliken) showed acrelein to be present.

It was found that old cracked gasoline imparts an acid reaction to water with which it is shaken. It, therefore, seemed possible, in view of the inactivity of the olefin bond, per se, that the catalyst might be an acid. This view was strengthened by the discovery that a trace of hydrogen chloride gas not only caused slight polymerization in fresh vapor phase gasoline, but also promoted profound oxidation. A trace of chlorine gas acted similarly. Glacial acetic acid, on the other hand, showed only a faint catalyzing action. Alpha-crotonic acid acted similarly to glacial acetic acid. A mixture of nickel and cobalt acetates, however, although practically insoluble in the gasoline, showed a considerable activating influence. Anhydrous calcium chloride was especially active, whereas the hydrated calcium chloride showed a greatly diminished activity. Table VII shows sample tests:

TABLE VII

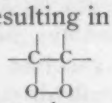
Catalyst	Days	Grams Residual Gum per 20 cc. Sample Gasoline
Trace hydrogen chloride	Start	0.0001
	5	0.1256
	9	0.2233
Trace chlorine	Start	0.0001
	10	0.1703
5 per cent glacial acetic acid	Start	0.0004
	16	0.0021
	45	0.0036
Mixed nickel and cobalt acetate crystals	Start	0.0004
	1	0.0004
	38	0.1040
Anhydrous calcium chloride (lumps)	Start	0.0012
	8	0.0350
	21	0.3123
Hydrated calcium chloride ($CaCl_2.6H_2O$ crystals)	Start	0.0004
	51	0.0827

We are leaving the complete theory of oxidation catalysts, along with new experimental data, for a paper to be presented in the near future on the question of determining the pseudo-gum stability of gasolines. It will be sufficient for the purpose at hand to point out the relative catalytic actions of weak and strong acids.

[4] Moureau and Dutraisse. C. R. 176, 624 (1923.)

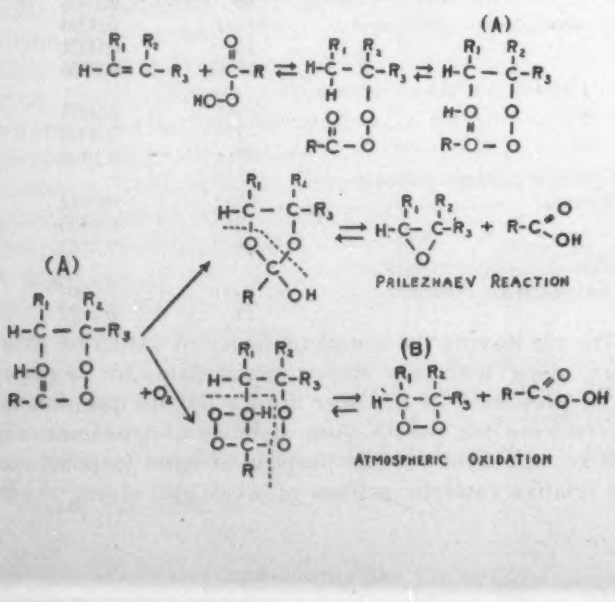
From the data, it would appear evident that if the catalyzing substances are acids, they must then be stronger than the common organic acids. This suggests the thought of per-acids, if one assumes for the present that such acids in hydrocarbon solution are indeed stronger than their respective parent acids. There can be little doubt that such per-acids are present in gasoline containing pseudo-gum. This is indicated by the fact that aldehydes, when exposed to an atmosphere of oxygen in the presence of sunlight, appear to form per-acids, along with pseudo-gum. The presence of peroxide in aldehydes, which in non-aqueous solution are exposed to the action of oxygen and light, may easily be shown with potassium iodide solution. Old cracked gasoline gives the same peroxide test. Here, too, may be mentioned the fact that when the undiluted aliphatic aldehydes, such as acetaldehyde or crotonaldehyde, are exposed for several hours to the action of oxygen and light, and then dissolved in water and evaporated on the water bath, residual gums are formed possessing characteristics of sugar derivatives. Similar residual gums are formed on evaporation of the wash water from gasoline containing pseudo-gum, as was mentioned previously. Such wash waters always appear to give the peroxide reaction.

If, then, the oxidation of gasoline is an auto-catalytic one, and if the catalytic agents are per-acids, they would have to react differently from the Prilezhaev reagents;[5] for auto-catalysis requires an increase in the amount of catalyst with time, whereas the Prilezhaev reaction would lead to a decrease in the amount of catalyst. Furthermore, the Prilezhaev reaction does not take account of atmospheric oxidation in its theoretical equation. Rather, the action of atmospheric oxidation on the olefinic bond seems to be the addition of two oxygen atoms instead of one,[6] resulting in compounds of the type

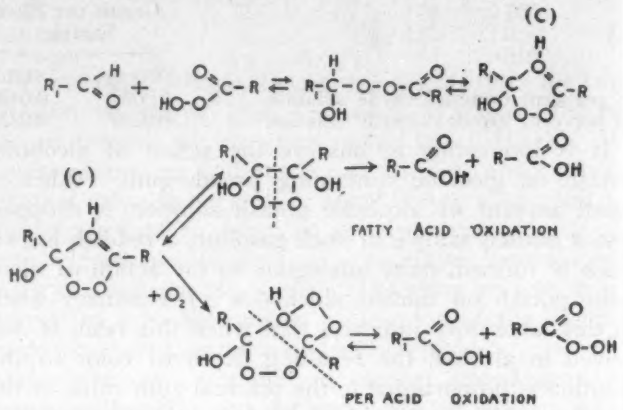


Such compounds appear then to oxidize themselves further, splitting the double bond completely with the formation of aldehydes and ketones, the former, at least, then absorbing an oxygen molecule[7] for the further formation of the catalytic per-acid.

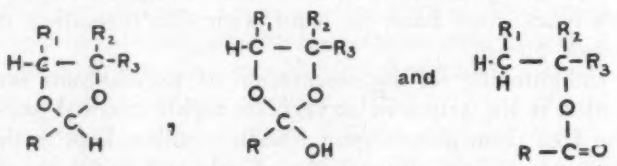
Taking the various factors heretofore cited into account, a simple scheme of reaction for the mechanism of pseudo-gum formation can be devised, which furthermore shows a relationship which may exist between such a reaction and the Prilezhaev reaction:



Thus, through the medium of reactive oxonium compounds of Type A, the per-acid would be regenerated, along with the hydrocarbon peroxide, B, which latter can break into an aldehyde and a ketone, the aldehyde being then further oxidized in the presence of the per-acid, somewhat as follows:



We are inclined to believe the pseudo-gum to be compounds of Type A and its degradation products, i.e., esters and acetals:

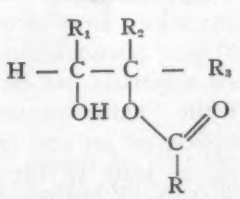


That compounds of Type C can play but a minor role in residual gum formation may be shown by exposing to sunlight acetaldehyde dissolved in an inert hydrocarbon medium. After an hour's exposure, the solution shows an intense peroxide reaction, but gives comparatively little residual gum. Table VIII illustrates this point, showing how the residual gum formation is very considerably increased when an unsaturated aldehyde (crotonaldehyde) is substituted for the saturated acetaldehyde.

TABLE VIII

	Grams Residual Gum	
	Before Exposure	After Exposure
10 per cent acetaldehyde solution	0.0069	0.0109
10 per cent crotonaldehyde solution	0.0055	0.0253

Type A compounds, when heated in non-aqueous solutions, would tend to form glycol of the type:[8]



which could then polymerize with the expulsion of water to form ester, olefins and furan derivative gums. Condensation might also occur with the less volatile aldehydes and ketons. In aqueous solutions, hydrolysis would occur to form di- and polyhydric alcohols, i.e., sugar derivatives. While we do not claim that the struc-

[5] Ber., 42, 4811 (1909.)
[6] Engler and Wild, Ber., 30, 1669 (1897); Engler and Weissberg, Ber., 33, 1094, (1900); Engler and Frankenstein, Ber., 34, 2933 (1901); H. A. Stephens, J. Amer. Chem. Soc., 50, 568 (1928.)
[7] See Kiss and Demeny, Rec. Trav. Chim., 43, 221 (1924).
[8] See, for example, any organic textbook for the action of organic acids on the substituted ethylene oxides.

ture of residual gum is exactly as here presented, we do believe that residual gum formation takes place along the general lines herein indicated, with compounds of Type A and its degradation products in the role of pseudo-gum.

If this theory is correct, and compounds of the type of A and its degradation products are the main constituents of pseudo-gum, then the behavior of gasoline samples evaporating on the steam bath is at once explicable. Some molecules of A combine, each with a molecule of oxygen, and then split up to regenerate the per-acid which started A on its career together with a molecule of B. B splits up into aldehyde and ketone, and the aldehyde molecule with one molecule of per-acid and one of oxygen manufactures two molecules of per-acid. The stability of the intermediate compounds A, B ad C, is naturally the factor which controls the rate of formation of pseudo-gum, subject, of course, to the effects of temperature, mass action and catalysts. Given, therefore, the same quantity of per-acid (or A, B. and C), the same temperature (that of the water bath), and the same time (that required to evaporate the 20 cc. of gasoline), the quantity of pseudo-gum formed during the evaporating period should be some multiple of the pseudo-gum originally present. The larger the sample taken for test, the greater will this be, because of the longer evaporating time and the more uncontrollable variables that will be introduced. Conversely, if the sample taken could be made infinitely small, then there would be no time for pseudo-gum formation, and the ratio of water bath method results to steam oven tests would approach 1:1. Work is in progress to determine whether or not such a method can be worked out, which will give results comparable to steam oven tests, but which will be easier to operate.

A factor even more important to the refiner than the pseudo-gum content of gasoline as it leaves the refinery is the rate of increase of pseudo-gum during the time the gasoline is in storage. The rate at which this pseudo-gum forms has been found dependent on the following factors: time of exposure to the atmosphere, concentration of oxygen in the atmosphere over the gasoline, the kinds and percentages of the various unsaturated compounds in the gasoline, the temperature of the system, the rate of diffusion of the oxygen through the gasoline, and the extent to which actinic rays or other catalyzing influences may have had access to the gasoline.

A reliable method for the determination of pseudo-gum stability is very much to be desired. If any such method is to have any practical application, however, and if the method is based on oxidation, then it should go without saying that such oxidation must be mild enough to be an index for actual oxidizing conditions such as are met with in the storage tanks. This point appears to have been overlooked by Voorhees and Eisinger, when they advocated their method for the determination of "potential gum." In this method, a 25 cc. sample of the gasoline to be tested is put into a flask under oxygen, and placed in an actively boiling water bath for five hours, after which the contents of the flask are evaporated in the steam oven. Table IX shows average results obtained by the use of the above-mentioned method, along with the order of gum stability as determined by actual field tests:

TABLE IX

Gasoline No.	"Potential Gum" Grams	Order of Pseudo-Gum Stability
1	0.0098	1
2	0.1993	2
3	0.1519	3
4	0.0345	4
5	0.2608	5
6	0.2207	6

The authors have been working for a considerable time on the problem of finding a reliable method for checking the pseudo-gum stability of gasolines. The path appears to lie in the direction of mild catalysts, and work along this line is now in progress.

Cracking by the True Vapor Phase Process

(*Continued from page 74*)

TESTS ON THE PRODUCTS

Finished Gasoline

Gravity 45.5 A.P.I. Doctor and corrosion negative

I.B.P.	125°F
10%	172
20%	200
30%	226
40%	250
50%	280
60%	316
70%	348
80%	372
90%	404
E.P.	437

Asphaltum

Penetration at 77° with 100 gram load	145
Color	black
Flash Point (O.C.)	425°F
Specific Gravity	1.0035
Melting Point	109°
Ductility	150 cm
Total Bitumen	99.09%
Insoluble in CS_2 (total)	0.91%
Organic matter Insoluble in CS_2	0.85%
Ash	0.06%
Adhesiveness	Good
Appearance	Smooth and Shiny

It will be noted from the above that there is extremely little carbon formation. Gasoline yield for the type of charging stock used may be considered extremely high. The value of the asphaltum may be considered as higher than that of refinery coke.

In the matter of yields it may be pointed out that yields in excess of 80 per cent of gasoline have been obtained with high grade charging stock such as West Texas and California gas oils, and between 70 per cent and 80 per cent of finished gasoline with Mid-Continent gas oil as charging stock.

The yields from the West Texas residuum were:

	Per Cent
Gasoline (437 E.P.)	51.0
Recycle Stock	6.9
Asphaltum	35.1
Gas and Loss	7.0
	100.0

Presented before Group Meeting on Refinery Technology, American Petroleum Institute, Chicago, Illinois, December 5, 1929.

Stabilization of Knock Rating, Gums and Color of Gasoline by Chemical Inhibitors

By GUSTAV EGLOFF, W. F. FARAGHER and J. C. MORRELL
Universal Oil Products Company Research Laboratory, Chicago, Illinois.

ONE of the urgent problems of the refining industry is the stabilization of gasoline with respect to knock rating, formation of gum, and color. The development of color and the formation of gum in stored gasoline have been known for some time. The problem of the depreciation of the knock rating of some cracked gasolines has arisen recently. Cases are known in which gasolines have dropped from a benzol equivalency of 40 per cent. to minus 13 per cent. after a month of commercial storage. Highly cracked gasolines depreciate particularly rapidly in regard to the knock rating, gum, and color. Such gasolines have been found to deteriorate markedly in a few days.

The extent to which stored gasoline depreciates depends upon many factors, among which are oxidation by air, light, and heat. Cracked gasolines are inherently more susceptible to depreciation than the straight-run products, owing to the difference in the amount and kind of unsaturated hydrocarbons present. However, changes in color, amount of gum, and knock rating of most properly refined cracked gasolines are so small as to cause no material difficulty. Although the field has not been investigated thoroughly, the character of the charging stock and the conditions under which it is cracked are probably the factors that determine the stability of the refined gasoline.

The formation of undesirable gums or resins is not limited to the petroleum industry. Industries dealing with turpentine, aldehydes, alcohols made from cracked gases, vegetable oils, and rubber are also confronted with the formation of gummy or resinous substances in their products. Oxidation by air seems to be involved in all these changes.

This paper presents the results of a study of the changes of knock rating, content of gum, and color which cracked gasoline undergoes and of methods of stabilizaton.

Chemical inhibitors have been found which substantially prevent the lowering of knock rating, stabilize color, and check gum formation during storage. Processes have been devised also for restoring the knock rating of deteriorated gasoline to its original benzol value.

CHANGES IN KNOCK RATING OF STORED CRACKED GASOLINE

A number of cracked gasolines which had been in storage for periods varying from six months to nearly two years were retested for knock rating. Several samples showed no change, but others had dropped by as much as 65 per cent. of the original benzol equivalent.

Table 1 shows the change in knock rating of a number of these cracked gasolines.

CHEMICAL INHIBITORS TO STABILIZE KNOCK RATING OF GASOLINES

When some gasolines are stored for relatively long periods of time, oxidation products are formed, some of which are gum or gum-forming substances. The oxidized products consist in part of peroxides, acids, aldehydes, and ketones. Coincident with their formation there is a drop in knock rating of some cracked gasoline during storage. Aniline, hydroquinone, naphthalene and anthracene have been found in this investigation to inhibit the changes that decrease the knock rating during storage. The same substances are also effective in preventing a reduction in knock rating when the gasolines containing them are subjected to the accelerated oxidation test for gums proposed by Voorhees and Eisinger, namely, heating the gasoline to a

TABLE 1
Knock Rating of Cracked Gasolines Before and After Storage

Months in Storage	Metal Container (Tinned iron) Condition after Storage	Cracked Gasoline Source	Cracked Gasoline A. P. I. Gr.	Cracked Gasoline I. B. P. °F.	Cracked Gasoline E. P. °F.	Benzol Equivalent Before Stor. Delco Motor Test	Benzol Equivalent After Stor. Delco Motor Test
6	Clean	Smackover	58.4	100	419	45	46
11	Red Gum Deposit	South Field Arkansas	62.3	110	367	35	15
11	Slight Deposit	South Field Arkansas	60.3	103	388	32	30
12	Clean	Mid-Continent	59.8	113	389	37	38
12	Clean	Mid-Continent	59.6	110	391	37	34
12	Clean	Mid-Continent	60.1	103	391	35	20
12	Clean	Mid-Continent	59.2	106	402	37	12
23	Clean	Mid-Continent	63.9	112	377	40	31
23	Clean	Mid-Continent	58.4	104	422	42	32
23	Clean	Mid-Continent	61.0	106	400	45	36

TABLE 2
CHEMICAL INHIBITORS AND KNOCK RATING PENNSYLVANIA CRACKED GASOLINE

	Original Gaso.	After Oxidation	Aniline	Hydroquinone	Urea	Phenol	Naphthalene	Anthracene
I. B. P. °F.	94	114	112	105	130	114	108	122
E. P. °F.	427	434	429	430	431	432	434	445
Color Saybolt	24	—16	—16	Yellow	—5	Yellow	0	—2
Mgs Gum Copper dish	19	220	55	16	56	139	241	75
Mgs Gum Glass dish	3	55	5	6	14	36	36	20
HYDROCARBONS[1]								
Percent—								
Unsaturates	24.0	23.0	..	..	..	..	..	..
Aromatics	22.9	22.5	..	..	..	..	..	..
Naphthenes	9.3	10.1	..	..	..	..	..	..
Paraffins	43.8	44.4	..	..	..	..	..	..
DELCO MOTOR TEST								
Benzol Equivalent Per Cent	40	29	39	40	34	31	35	34
MID-CONTINENT CRACKED GASOLINE								
I. B. P. °F.	103	114	106	110	108	107	108	118
E. P. °F.	320	335	319	313	301	302	313	312
Color Saybolt	30	7	—16	13	26	16	28	28
Mgs Gum Copper dish	68	475	389	26	198	131	126	75
Mgs Gum Glass dish	1	136	29	3	13	16	5	3
HYDROCARBONS								
Percent—								
Unsaturates	36.2	41.1	..	..	..	..	..	..
Aromatics	12.0	7.8	..	..	..	..	..	..
Naphthenes	11.9	11.7	..	..	..	..	..	..
Paraffins	39.9	39.4	..	..	..	..	..	..
DELCO MOTOR TEST								
Benzol Equivalent Per Cent	56	37	34	52	40	47	47	47

[1]Egloff and Morrell, J. Ind. Eng. Chem., 18, 354 (1926). This method was used throughout.

temperature of 212°F. in an atmosphere of oxygen for a period of five hours.

In a set of experiments using a Pennsylvania cracked gasoline, the accelerated oxidation test lowered the benzol equivalent from 40 to 29 per cent. The addition of 0.1 per cent by weight of aniline or hydroquinone to the cracked gasoline preserved the knock rating when the gasoline was subjected to the same accelerated oxidation test conditions. Naphthalene and anthracene also acted as inhibitors but to a lesser degree than aniline and hydroquinone.

In another set of experiments using a Midcontinent cracked gasoline, aniline gave poor stability while the other inhibitors mentioned gave good results.

Table 2 shows the detailed experimental results.

Table 3 covers data of a Mid-Continent cracked gasoline of 410°F. end point which was stabilized by chemical inhibitors, as far as its knock rating was concerned.

Analine is a stabilizer and also has antiknock properties of its own when added to gasoline. The increase of four per cent. of benzol is the calculated amount for the quantity of aniline added.

A California cracked gasoline showed marked stability in regard to knock rating when subjected to the accelerated oxidation test. This would indicate that the oxidation products in this gasoline did not affect its knock rating. Although the gum was increased by oxidation, the benzol equivalent was decreased only from 55 to 51 per cent., and a Pennsylvania cracked gasoline

TABLE 3

	Color Before Oxidation	Color After Oxidation	Gums mg. per 100 cc. Copper Dish	Benzol Equivalent % (Delco Motor test)
Gasoline Alone				
Before oxidation	20	..	25	32
After oxidation	..	Yellow	331	15
With Inhibitors (0.1 per cent. by wt. of gasoline)				
Aniline	Yellow	Yellow	9	36
Dimethylaniline	16	Yellow	22	30
Diethylamine	16	Yellow	337	30
Hydroquinone	20	Yellow	11	31
Anthracene	18	Yellow	60	30

subjected to the same conditions of oxidation depreciated in benzol value from 40 per cent. to 29 per cent., while a Mid-Continent motor fuel dropped from 56 per cent. to 37 per cent. This difference may be due to the nitrogen compounds present in the California cracked gasoline which act as antioxidants or inhibitors.

From a study of the data there appears to be a relationship between the depreciation in knock rating and the increase in gum formation. Generally speaking those materials which inhibit gum formation also check depreciation in knock rating, although there are some exceptions to this generalization, e.g., diethylemine will inhibit the depreciation of knock rating under the test conditions but does not prevent increase in gum. On

TABLE 4

Accelerated Oxidation Treatment of California Cracked Gasoline

	Original Gasoline	After Oxidation
I. B. P.—End Point °F.	92 - 428°	125 - 435°
Color, Saybolt	30	Yellow
Mgs. Gum, (copper dish)....	11	77
Mgs. gum, (glass dish).....	Trace	32
	Hydrocarbons, in per cent.	
Unsaturates	19.4	23.4
Aromatics	25.2	24.1
Naphthenes	13.4	12.4
Paraffins	42.0	40.1
	Delco Motor Test	
Benzol Equivalent, per cent. ..	55	51

Table 5 summarizes the changes in knock rating of four cracked gasolines subjected to the accelerated oxidation test.

TABLE 5

Gasoline—	I.B.P.	End Point	Benzol Equivalent, Per Cent. Delco Motor Test Gasoline Original Gasoline	Gasoline after Oxidation
California	92	428	55	51
Pennsylvania	94	427	40	29
Mid-Continent 103		320	56	37
Mid-Continent ...107		411	36	21

the contrary it appears to promote gum formation. Other substances which act as inhibitors in preventing knock depreciation fail to prevent increase in gum.

The formation of easily oxidizable gum-forming materials is accompanied in some cases by a depreciation in knock rating. It cannot be generalized, however, that the two phenomena are directly related because the addition of inhibitors may prevent decrease in knock rating without preventing gum formation.

GUM IN CRACKED GASOLINE

The formation of gums in highly cracked gasolines was noted by Hall[2] in 1915. He recognized that it was an air oxidation process and unless the gasoline was properly refined would "clog and stick up the valves of any engine in which it may be used." With some cracked gasolines gum formation is still a problem from a theoretical and a practical viewpoint.

Moureu and Dufraisse[3] have made an extensive study of the effect of anti-oxidants in preventing the oxidation of sensitive materials such as furfural, aerolein, styrol, linseed oil, which ordinarily under oxidizing conditions would develop color or form gum-like substances. These authors have found that a mere trace of pyrogallol will prevent the oxidation of acrylic aldehyde for example even in an atmosphere of oxygen.

The National Benzol Association of England[4] has reported upon the gum or resin formation in benzol motor fuels. They have found that tricresol acts as an inhibitor of the formation of gum. Some experiments indicate that a chemical inhibitor in a benzol motor fuel may act as an accelerator in some containers. Gum formation is also dependent upon the percentage of inhibitor added; a small quantity may act as an inhibitor of gum and a larger quantity as an accelerator.

Water has some influence on gum formation, but quantitative data are lacking[5]. Water may act either as a gum inhibitor or accelerator. Hence, it is extremely important that in all studies of gum formation in motor fuels the quantity of inhibitor, presence of water, type of container, oxidizing agent, temperature or light effects should be reported.

When cracked gasolines are subjected to oxidation by air or oxygen, the formation of gum increases. Of the gasolines used in these tests those from California and Pennsylvania were found to be more resistant to gum formation than the gasolines from the Mid-Continent. The data are shown in Table 6.

TABLE 6

Cracked Gasoline—	Mgs. Gum Copper Dish Method	Mgs. Gum Copper Dish Method
California before oxidation.....	11	Trace
California after oxidation	77	32
Pennsylvania before oxidation	19	3
Pennsylvania after oxidation 220		55
Mid-Continent before oxidation	9	2
Mid-Continent before oxidation.....	68	1
Mid-Continent after oxidation 619		97

A series of chemicals were tested as inhibitors of gum formation during exposure to sunlight in the presence of oxygen. The inhibitors were added to the gasoline in weights of 0.1 grams per 100 cc. Naphthalene, urea, pyrene, phthalic anhydride, and carbazole were effective in a Mid-Continent cracked gasoline.

This cracked gasoline had a gravity of 58°F A. P. I., an initial boiling point of 110°F., and an end point of 437°F.

Table 7 shows the effect of chemical inhibitors upon gum formation when the gasoline was exposed to sunlight for 24 hours.

The gum in the original gasoline was six milligrams per 100 cubic centimeters, and after exposure to sunlight, 15 milligrams.

TABLE 7

Chemical Inhibitor—	Mgs. Gum Glass Dish Method
Naphthalene	2
Pyrene	2
Phthalic anhydride	4
Urea	6
60 per cent. Carbazole	6

Urea in another gasoline increased the gum; the gasoline after exposure to sunlight showed six milligrams and the gasoline plus urea, 78 milligrams. This behavior emphasizes the fact that a chemical will not necessarily act as an inhibitor under all conditions.

Several cracked gasolines were subjected to the accelerated oxidation tests with and without the use of chemical inhibitors. It was found that aniline, dimethyl aniline, urea, hydroquinone, and anthracene were ef-

[2] J. Inst. Petr. Tech., Page 147, 1915.
[3] Moureu and Dufraisse, Chem. Rev. 3, July (1926).
[4] Nat'l. Benzol Assoc. of England, Report of Research Com. p. 61, (1929).
[5] Nat'l. Benzol Assoc. of England, Report of Research Com., p. 67, (1929).

fective in checking gum formation. The tabulated data present the experimental results obtained:

TABLE 8

Pennsylvania Cracked Gasoline

(I.B.P. 94°F.—427°F. E. P.)

	Original Gasoline	After Oxidation	Inhibitors Aniline	Urea
Mgs. gum, Copper Dish	19	220	55	16
Mgs. gum, Glass Dish	3	55	5	6

MID-CONTINENT CRACKED GASOLINE

(I.B.P. 103°F. E. P.)

			Hydroquinone	Anthracene
Mgs. gum, Copper Dish	68	475	26	73
Mgs, gum, Glass Dish	1	136	3.2	2.5

MID-CONTINENT CRACKED GASOLINE

(I.B.P. 110°-410°F. E. P.)

			Aniline	Dimethyl-aniline	Hydroquinone
Mgs. gum, Copper Dish.	25	331	9	22	11

COLOR STABILITY

Very little is known about the composition of the coloring matter in gasoline. It has been generally assumed to result from the chemical changes of the more highly unsaturated compounds. Factors favoring the formation of gum in cracked gasolines, such as light, heat and oxidizing agents usually cause the development of color.

The decomposition of acid esters in improperly refined gasoline, and the reaction products of sulfuric acid generated from the alkyl sulfuric acids are responsible sometimes for the color. Elementary sulfur generally causes discoloration of cracked gasoline.

Some gasolines are not color stable when they are subjected to sunlight or ultra-violet light; or are stored for a long time. A high summer temperature may develop color in a short time. A deep yellow, green, brown, pink, or wine red color develops, depending upon the gasoline. This color change may be prevented by small percentages of chemical inhibitors.

A gasoline produced from a Mid-Continent cracking stock, treated with three pounds of 66° Be. sulfuric acid per barrel, water washed, neutralized and distilled with fire and steam at a temperature of 350°F., was used in one series of color-stability tests. The gasoline had a gravity of 58° A. P. I., an initial boiling point of 110°F., and an end point of 437°F.

One hundred cubic centimeter samples of this gasoline, containing 0.1 gram of a number of chemicals, were exposed to 24 hours of sunlight. The changes in the color and the gum content were then determined. The data are shown below:

TABLE 9

Color before exposure	22
Color after exposure (no stabilizer present)	17
Mgs. gum/100 cc. by glass dish method before exposure	6
after exposure	15

Stabilizer Used—	Color after 24 Hours of Sunlight	Mgs. Gum / 100 cc. Glass Dish Method
Gum Camphor	22	20
Phenanthrene	21	18
Urea	21	6
Pseudo-cumene	21	9
Acenaphthalene	21	9
L-Methyl Naphthalene	20	9
Anthracene	20	14
Naphthalene	20	2
Fluorene	20	11
Tetralin	19	13
B-Naphthol	19	14
Hydroquinone	19	12
Phthalic anhydride	19	4
Phthalimide	17	7
60 per cent. Carbazole	15	6
Pyrene	10	2

In a second series of tests a gasoline with a color of 20 Saybolt made by treating a Mid-Continent pressure distillate with three pounds of 60°Be. sulfuric acid per barrel, water washing, neutralizing, and rerunning at a still temperature of 375°F., was treated with 0.1 per cent. by weight of the inhibitors. The gasoline without a stabilizer dropped to a color of 12 Saybolt on exposure for eight hours in sunlight. The results with the inhibitors are as follows:

TABLE 10

Inhibitor—	Color after Sunlight Exposure for 8 hours
Pseudo-cumene	16
L-Methyl naphthalene	16
B-Methyl naphthalene	16
Fluorene (80 - 85 per cent pure)	16
Pyrene	16
Acenaphthane	16

A third series of tests was made with a cracked Mid-Continent gasoline, the color of which was 18 Saybolt. This gasoline when exposed to sunlight for three days without the addition of an inhibitor dropped in color to 14 Saybolt. The results obtained by using 0.1 per cent. of weight of various inhibitors are as follows:

TABLE 11

Inhibitor Added to Gasoline—	Color after Sunlight Exposure for 3 days
Tetralin	21
Urea	21
Phthalimide	19
Naphthalene	19
Camphor	19
Anthracene	18
Phenanthrene	18
Phthalie anhydride	18
B-Naphthol	16
Carbazole	14

The color of another Mid-Continent cracked gasoline, with and without the addition of traces of naphthalene and anthracene, was determined before and

after exposure to sunlight in an atmosphere of oxygen. The original color of the cracked gasoline before treatment was 30 Saybolt. The color dropped during the exposure to 22 Saybolt when no inhibitor was present. However, when the inhibitors were used the color fell only to 28 Saybolt.

It must be acknowledged that a given chemical inhibitor may be effective as a color stabilizing agent with one gasoline and not with another under the same conditions.

REGENERATING OR RESTORLING ANTIKNOCK PROPERTIES OF GASOLINE

A series of experiments was made to develop methods for restoring or regenerating the antiknock properties of depreciated gasoline.

The first tests were made with refining agents and a Pennsylvania cracked gasoline having an original benzol equivalent of 40 which had been depreciated in knock rating by the accelerated oxidation treatment to a value of 29 per cent.

Another set of tests was made with a Mid-Continent cracked gasoline which had been depreciated by the same method from a benzol value of 56 to a value of 37.

Good results were obtained in restoring the antiknock properties of the Mid-Continent cracked gasoline by treatment with any of the following treating agents; fuller's earth, 75 per cent. sulfuric acid, 95 per cent. sulfuric acid, 16° Be. caustic soda, 40° Be. caustic soda; and borax in the rerun stills. With the same treating agents applied to a Pennsylvania cracked gasoline, all but the fuller's earth and the 40°Be. caustic soda gave partial or full regeneration.

The detailed results on regeneration are shown in the following table:

TABLE 13

	Original Gasoline	Gasoline After Oxidation	Sodium Hydrogen Sulfite	Strannous Chloride	Acetite Acid and Zinc
Color	20	Yellow	Light Orange	Yellow	Yellow
Gum - Mg./100 cc. Copper dish method	25	330	330	..	326
Per cent. Benzol Equivalent	32	16	30	28	30

Another set of experiments for restoration was made with a Mid-Continent cracked gasoline using reagents having reducing properties. The gasoline was exposed to sunlight in an atmosphere of oxygen to depreciate its knock rating. Sodium hydrogen sulfite, stannous chloride, and acetic acid and zinc restored the depreciated gasoline from a knock rating of 16 per cent. practically to its original benzol equivalent of 32 per cent.

The treatments were as follows:

1. Washing the depreciated gasoline with 10 per cent. by volume of a saturated solution of sodium hydrogen sulfite and then washing with water.
2. Washing with 10 per cent. by volume of a saturated solution of stannous chloride.
3. Refluxing for two hours with 10 per cent. by volume of glacial acetic acid and zinc dust, washing with water, neutralizing with caustic soda and then water washing.

The results are shown in the following tabulation:

TABLE 12
Restoration of Knock Rating
Pennsylvania Cracked Gasoline

	Original Gasoline	After Oxidation	Three lbs. per bbl. Fullers earth	Rerun over Borax	Three lbs. 95% H_2SO_4	Three lbs. 75% H_2SO_4	3 per cent. 16° Be. NaOH	3 per cent. 40° Be. NaOH
I. B. P. °F.	94	114	106	115	119	120	114	112
E. P. °F.	427	434	434	439	436	438	434	437
Color Saybolt	24	—16	—11	+16	30	28	—16	—11
Mgs Gum Copper dish	18.7	220	257	30.9	5.1	10.5	178	144
Mgs Gum Glass dish	2.3	55	35	2.8	2.5	2.8	38	22
Hydrocarbons								
Per cent.								
Unsaturates	24.0	23.0	..	.	..	..	..	..
Aromatics	22.9	22.5	..	.	..	..	..	..
Naphthenes	9.3	10.1	..	..	..	..	..	..
Paraffins	43.8	44.4	..	..	..	..	..	..
Delco Motor Test								
Benzol Equivalent per cent..	40	29	27	40	40	37	35	29
Mid-Continent Gasoline								
I. B. P. °F.	103	114	118	114	119	120	112	114
E. P. °F.	320	335	314	310	315	307	304	302
Color Saybolt . .....+30		+7	10	+16	+18	+16	+16	+15
Mgs Gum Copper dish	68	475	580	83	55	73	347	219
Mgs Gum Glass dish	1	136	150	2	1.0	1.5	78	47
Hydrocarbons								
Per cent.								
Unsaturates	36.2	41.1						
Aromatics	12.0	7.8						
Naphthenes	11.9	11.7						
Paraffins	39.9	39.4						
Delco Motor Test								
Benzol Equivalent per cent.	56	37	48	50	51	51	50	52

Other reducing agents would probably show similar results in regeneration of the gasoline. These data lend added support to the theory that the chemical inhibitors act as anti-oxidants.

CONCLUSIONS

1. Although most cracked gasolines are satisfactorily stable during storage with respect to color, gum and knock rating, there are some that deteriorate.

2. There is no regularity in the formation of gum and lowering of knock rating.

3. The accelerated oxidation test for gums is applicable as an accelerated test for depreciation of knock rating of a gasoline.

4. Chemical inhibitors have been found which prevent loss of knock rating during accelerated oxidation.

5. New chemical inhibitors have been found which prevent gum formation during the accelerated oxidation of gasoline. It is expected that they will be effective in stored gasoline.

6. New chemical stabilizers of color for stored gasoline have been found.

7. Processes for the restoration of cracked gasoline which had depreciated in knock rating have been developed.

Some Phenomena of Gum Determinations In Motor Fuel

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Paper Delivered at Tenth Annual Meeting, American Petroleum Institute, Chicago, Illinois, December 5, 1929

WITH the recent and widespread interest shown in the meaning and interpretation of gum tests as related to gasoline storage and engine performance, numerous testing methods have been proposed. It is safe to say that most refiners of petroleum have adopted as standard practice in their laboratories at least a few of the proposed testing methods. Although somewhat dubious as to their value, they continue to accumulate data with the expectation that at some future date they will be proved of real value and given a definite significance.

Briefly reviewing the situation as it stands today, it might be said that attempts have been made to determine:

1. The so-called preformed or actual gum existing in gasoline at a given time, and
2. The potential gum-forming tendency inherent in the gasoline.

The very excellent research work of Messrs. Voorhees and Eisinger,[1] in correlating so-called preformed or steam oven gum content with engine performance, stands out as possibly giving a real solution to the first of these problems. If the gum deposited in a steam-oven test is not so-called preformed gum but rather, as has been suggested, a condensation product formed by the steam oven test conditions, the addition of gum-forming deterrents may upset the correlation of steam oven gums with engine performance.

The second problem, that of estimating the extent to which actual gum formation will take place under long-time storage conditions, is by nature very much more complex than the first problem, and is the one which has given rise to this present discussion. The discussion is incomplete, but is presented to make available points considered of general interest.

The controlled oxygen absorption method has been suggested for a measure of potential gum. This method has been used in the study of gasoline characteristics, in conjunction with the steam oven method which measures the so-called preformed gum, and also with the copper dish method which may measure both the potential gum and so-called preformed gum.

In this study, the oxygen gum method used was substantially that described by Voorhees and Eisinger, viz., oxidizing 25 cc. of gasoline sample in a 500 cc. glass container filled with oxygen, rubber-stoppered and immersed in a water bath at boiling temperature for five hours, cooling, decanting into a 150 cc. crystallizing dish, together with alcohol and benzol washings, and evaporating to constant weight in a steam atmosphere held at 325-340° F. The residue is calculated on a basis of 100 cc. of gasoline. The only possible divergence from the Voorhees and Eisinger method was that of adding a metal clamp to secure the rubber stopper in place, thereby assuring prevention of leakage of oxygen.

The copper dish gum method was slightly modified from method described in Technical Paper 323-B. One hundred cc. of the gasoline to be examined was placed in a freshly polished hemispherical dish of spun copper, approximately 3½in. diameter, and evaporated to dryness on an actively boiling steam bath without any steam coming in contact with the outer surface of the dish higher than the level of the gasoline. The amount of gum was determined by difference in weight of cooper dish before filling with gasoline and after evaporation. This method was modified to the extent of providing a 6 in. guard around the steam bath to prevent air currents from passing directly over the dish.

The steam oven gum method followed utilized a modified form of Cooke's method, Bureau of Mines Report, Series No. 2686 (1925). Fifty cc. of the gasoline to be examined were placed in a 150 cc. crystal-

[1] Sect. II, Addresses and papers delivered at Ninth Annual Meeting of Amer. Pet. Inst., Chicago, Dec., 1928.

lizing dish, and evaporated to constant weight in an atmosphere of steam held between 325-340°F.

The impossible coordination of copper dish and oxygen absorption gums is indicated in characteristic results tabulated in Tables 1 and 2.

TABLE 1

Tests Illustrating Impossibility of Coordination of Copper Dish Gums and Oxygen Absorption Gums

Sample No.	Liquid Phase Cracked Gasoline Copper Dish Gum (mg. per 100 cc.)	Oxygen Gum (mg. per 100 cc.)	Saybolt Color
1	163.8	32.2	+11
2	125.0	16.8	+10
3	11.1	1.6	+29
4	190.9	8.0	+29
5	73.6	1.0	30+
6	8.0	99.2	+23
7	3.3	17.2	+30
8	9.2	17 6	+30
9	8.0	40.0	+29

TABLE 2

Texts Illustrating Impossibility of Coordination of Copper Dish and Oxygen Absorption Gums

Sample No.	Vapor Phase Cracked Gasoline Copper Dish Gum (mg. per 100 cc.)	Oxygen Gum (mg. per 100 cc.)	Saybolt Color
1	341.5	1.0	26
2	15.9	1.2	23
3	699.6	12.4	17
4	37.8	4.4	28
5	35.6	1.6	19
6	39.1	1583.0	+12
7	40.7	696.4	4
8	32.2	1214.4	30
9	20.6	89.6	+24

Further proof of lack of coordination of copper dish and oxygen absorption gum is given in gum tests on like boiling point gasolines, prepared in three different manners from the same vapor phase cracked distillate. A blank sample prepared by simple distillation through a laboratory fractionating column showed 1000 milligrams by copper dish method and 1600 milligrams by oxygen absorption method. A gasoline produced by simple distillation of the yellow naphtha after treating method No. 1 showed a copper dish gum of 1054 milligrams and an oxygen absorption gum of 128 milligrams. A gasoline produced by simple distillation after treatment of vapor phase distillate by method No. 2 showed 1001 milligrams of copper dish gum and 4 milligrams of oxygen absorption gum.

TABLE 3

Effect of Metals on Gum Tests

Sample No.	14 mg. per 100 cc.	15 mg. per 100 cc.	16 mg. per 100 cc.	17 mg. per 100 cc.	18 mg. per 100 cc.
Oxygen Absorption Test (Regular)	7.6	24.8	14.0	194.8	24.8
Oxygen Absorption Test with Metal in Oxidation Phase					
Copper (partial immersion)	2729.6	2377.6		1120.8	37.6
Copper (total immersion)			622.6	1185.6	49.6
Steel	1610.8	1555.2			
Oxygen Absorption Test with Metal Dishes in Reduction Phase					
Copper Dish	9.6	22.0			
Steel Dish*	50.4	—0.0			

*Not reliable due to scaling of steel dish.

These results may be explained by catalytic effect of copper causing the high copper dish gum. It was suggested that trial be made of the effect of copper, and also of steel, both upon the oxygen digestion stage and upon the steam oven evaporation stage of the regular oxygen absorption method. A few of the results of such combinations are given in Table 3. The data, although not extensive, bring out the important point that metals do play a strong role in catalyzing oxidation reactions of this nature, steel being less active than copper.

The effect of metals is also brought out in four weeks storage tests, made on samples 7, 8, 9, and 10.

TABLE 4

Behavior of Vapor Phase and Liquid Phase Cracked Gasoline in Storage with Metals and Their Visible Bowl Tests

Sample No.	7 Before	7 After	8 Before	8 After	9 Before	9 After	10 Before	10 After
One Month Visible Bowl								
Color	0	0	22	0	+26	16	30+	19
Copper dish gum	959.9	3638.4	84.8	173.1	553.0	236.6	3.1	1151.6
Steam oven gum	41.6	1560.0	6.2	1100.0	4.4	1242.2	0.2	453.4
Oxygen abs. gum	3256.4	4980.0	13.2	3102.0	758.8	3831.6	19.2	1440.0
Gum deposit	....	None	....	None	....	heavy gum	....	heavy gum
One Month Dark Storage in Glass								
Color	0	0	22	10	+26	23	30+	30+
Copper dish gum	959.9	1217.0	84.8	77.6	553.0	333.5	3.1	3.0
Steam oven gum	41.6	43.2	6.2	19.2	4.4	67.8	0.2	4.6
Oxygen abs. gum	3256.4	2910.0	13.2	15.2	758.8	1506.8	19.2	0.8
One Month Dark Storage in Glass (copper strip)								
Color	0	0	22	0	+26	13	30+	28
Copper dish gum	959.9	2889.3	84.8	132.5	553.0	1150.5	3.1	9.1
Steam oven gum	41.6	....	6.2	49.6	4.4	437.0	0.2	4.8
Oxygen abs. gum	3256.4	1016.0	13.2	158.0	758.8	1898.8	19.2	176.8
One Month Dark Storage in Glass (Iron strip)								
Color	0	0	22	12	+26	14	30+	30+
Copper dish gum	959.9	1312.1	84.8	85.0	553.0	682.5	3.1	4.0
Steam oven gum	41.6	46.6	6.2	....	4.4	85.4	0.2	6.4
Oxygen abs. gum	3256.4	1769.2	13.2	23.6	758.8	2097.6	19.2	42.7

All gums in milligrams per 100 cc.

Note—Samples 7, 8, and 9 were vapor phase, cracked gasolines, while sample 10 was a liquid phase cracked gasoline.

C. D.=Copper dish gum.
S. O.=Steam oven gum.
O.=Oxygen absorption gum.

The tests were made in gallon glass containers vented to air under the following conditions:

1. Exposed to sunlight
2. In dark
3. In dark, with addition of copper strips
4. In dark, with addition of steel strips.

The storage with steel and copper gives instances of acceleration in formation of steam oven and oxygen absorption gum, the copper showing greater activity. These data are shown in Table 4.

The results in Table 4 indicate that a four weeks' period of visible bowl exposure was severe enough to bring gum content of all samples to a relatively equal basis, regardless of the initial gum tests, or of the character of the original stock. Samples 7, 8 and 9 are vapor phase cracked products, and sample 10 is a liquid phase cracked product. The dark storage tests show that copper dish gum is more indicative of steam oven gum formation in such storage than is oxygen gum. This indication by copper dish gums is contrary to expectations.

The phenomenon of deposition of heavy gums from two of the samples exposed to sunlight storage could not be traced to any particular cause. It is interesting to note in this connection the results given in Table 5 which show gum deposit from treated straight run gasoline, even though gums by copper dish, steam oven, and oxygen absorption methods on original samples are all very low. The samples used for data in Table 5 were exposed to sunlight for four days.

Although the samples used for data in Table 4 show considerable change of color on sun exposure, along with increase of gum content, Table 6 covers instances where exposure of treated liquid phase cracked gasoline over a four weeks' period caused gum content to be materially increased and color to be changed but slightly.

Treated cracked gasoline was stored in a 15,000 barrel vented tank for six months with change in gum characteristics and color as follows:

	Copper Dish	Steam Oven	Oxygen Absorption	Color
Before	33 mg.	0.2 mg.	30.6 mg.	30+
After	45 mg.	2.0 mg.	20.4 mg.	+29

A sample of the gasoline after storage was exposed to 27 hours of good sunlight in a vented five gallon glass bottle, and the gum and color tests on it after exposure were as follows:

Copper dish gum	72.7
Oxygen gum	144.0
Steam oven gum	26.0
Color	0

The sample after sun exposure showed gum deposit when used in an automobile engine, whereas another sample taken after storage, but without sun exposure, showed no gum deposit when similarly used.

The foregoing shows the variations encountered with the three general gum testing methods, and also points out the factors of metal contact and sunlight as agents affecting storage stability and engine performance. The oxygen absorption method seemed, theoretically, to be the logical method to correlate with potential gum, and further study of this method and of possible variables in the same was carried on in special equipment.

The apparatus was essentially as shown in Figure 1—constant temperature bath, manometer, oxygen

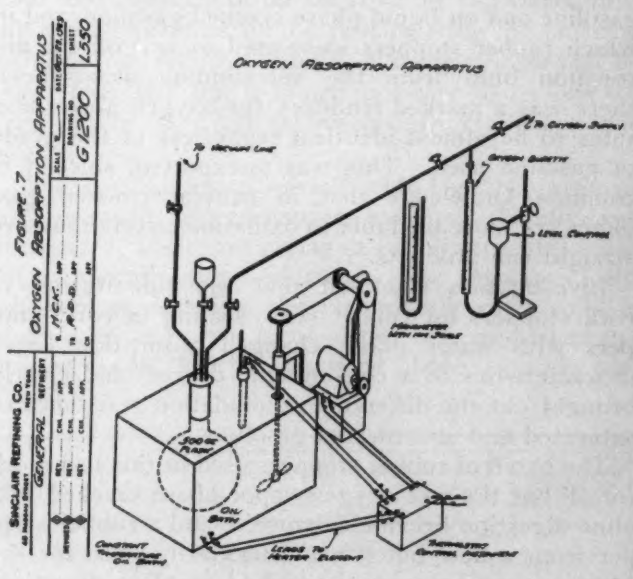


FIGURE 1

burette, and 500 cc flask equipped with stopcock connection. The 500 cc. flask was of the short ring neck variety in order to permit placing the stopper and stopcocks close to the bath. This avoided to a large extent condensation in these regions and its influence on volume readings.

Due to the temperature of the bath varying between 211° F. and 215° F., it was necessary to choose a definite period to read the volume. To that end the volume was always read when the temperature of the bath was on the way down and had arrived at

TABLE 5
Visible Bowl Test of Straight Run Gasoline
Four Days Exposure

Sample	138-1A	138-2A	138-2C	138-3B	139-A
Tests before Visible Bowl:					
Color	30+	28+	30+	30+	27+
Copper dish gum	3.8mg.	3.8mg.	3.7mg.	3.7mg.	3.9mg.
Steam oven gum	0.0	0.0	0.0	0.0	0.0
Oxygen abs. gum	10.0	7.0	5.0	8.0	4.0
Tests after Visible Bowl:					
Color	30+	30+	30+	30+	30+
Copper dish gum	6.4mg.	7.4mg.	56.2mg.	8.0mg.	8.6mg.
Steam oven gum	4.4	6.6	3.4	4.6	5.2
Oxygen abs.gum	22.0	25.6	15.7	10.8	18.0
Gum deposit	None	None	Gum	Trace gum	Gum

Note—C. D.=Copper dish gum.
S. O.=Steam oven gum.
O_2=Oxygen absorption gum.
Gums reported in milligrams per 100 cc.

TABLE 6
Visible Bowl Test of Liquid Phase Gasoline
Four Weeks Exposure

Sample No.	1	2
Tests before Visible Bowl:		
Color	30+	30+
Copper dish gum	101.9 mg.	3.0 mg.
Steam oven gum	0.2	0.3
Oxygen abs. gum	6.0	6.0
Tests after Visible Bowl:		
Color	28+	30+
Copper dish gum	1015.6 mg.	1189.8 mg.
Steam oven gum	279.2	443.4
Oxygen abs. gum	818.8	684.0
Gum deposit	None	None

Note—Gums reported in milligrams per 100 cc.

212° F. The reason for this was that the temperature came down much slower than it went up.

The apparatus was charged with oxygen and sample in the following manner:

The system was completely filled with oxygen and evacuated six times to 26 inches of mercury. On the seventh time it was evacuated to 20 inches and the sample (5 cc.) of stock to undergo test was charged. In a few minutes pressure equilibrium was established by means of level control on the oxygen burette, and sufficient oxygen admitted to fill the burette three-fourths full.

All runs were made at atmospheric pressure to avoid the difficulties usually encountered with pressure or high vacuum.

Dry oxygen for this work was prepared by passing commercial oxygen first through a wash bottle containing concentrated sulfuric acid and then through a calcium chloride drying tube. The wet oxygen was prepared by first drying in the above manner and then humidifying by passage through a wash bottle containing distilled water. No quantitative determinations of moisture content were made.

Tests on the stocks used in this work are shown in Table 7.

TABLE 7

Tests on Gasoline Used in Oxygen Asborption Apparatus

	Straight Run	Liquid Phase	Vapor Phase
Color	30+	22	+26
Copper dish gum	1.2	8.3	553.0
Steam oven gum	0.0	8.0	4.4
Oxygen abs. gum	9.2	40.4	758.8

Note.—Gums reported in milligrams per 100 cc.

In the first tests which were made on straight run gasoline and on liquid phase cracked gasoline, and in which rubber stoppers were used to seal off the absorption bulb from the surrounding atmosphere, there was a marked tendency for oxygen absorption rates to be almost identical regardless of the grade of gasoline used. This was unexpected, since it is common knowledge that, in general, cracked gasolines are more unstable to oxidation effects than are straight run products.

Investigation disclosed that the substitution of cork stoppers for rubber ones, sealing in cork stoppers with water glass, changed absorption curve characteristics to a considerable degree, and clearly brought out the difference in oxidation resistance of saturated and unsaturated gasolines.

The batch of rubber stoppers used in this test work for all but the wet oxygen vapor phase cracked gasoline digestion became exhausted, and a rubber stopper from a new batch was necessarily used for the wet oxygen vapor phase cracked gasoline digestion. Difference in composition of rubber was given as the reason for wet oxygen showing less acceleration as compared to dry oxygen in the case of a rubber-stoppered vapor phase cracked gasoline digestion. It was noted in instances of regular oxygen absorption gum tests that, when using rubber stoppers from certain batches, the rubber tended to disintegrate. Such results are not included in data of this paper. The first batch of rubber stoppers used in obtaining data of oxygen absorption curves did not show disintegration, but did increase in size with use. The rubber stopper used for the wet oxygen vapor phase cracked gasoline digestion did not show as much distortion.

The oxygen absorption test work supplying data for Figure 2, 10, and 11 brings out the following points:

1. The use of equipment which is entirely inert to possible physical and chemical effects is important.
2. The presence of moisture accelerates oxidation. The use of dry oxygen or oxygen with controlled moisture concentration is essential for uniform results.

Further study of these points, as well as of air contamination, is contemplated.

The work discussed in the paper is not complete or conclusive. It indicates, however, that the gum determinations by copper dish method, steam oven method, and oxygen absorption method as practiced, cannot be correlated with each other or with storage performance where acceleration of gum formation by light or by metal catalysis is possible. Furthermore, there may be other accelerators such as moisture, which influence prediction of commercial performance by laboratory test.

2750 Tons of Lead for Ethyl Gasoline in 1929

AN interesting sidelight on refining industry endeavor is the even increasing consumption of metallic lead paralleling the growth in popularity of Ethylized motor fuels. Prior to the development and commercial exploitation of Ethyl gasoline the refining industry confined its consumption of lead to such items as paints, cable covering, sheet lead for insulation of acid containers, and the heavy chemical litharge of which great quantities are annually consumed in preparing "Doctor" solution for chemical treatment of distillates. As the Ethyl gasolines gained in popularity a new and ever widening market for metallic lead was created. It is estimated by the Lead Industries Association that in 1929 the consumption of lead in the manufacture of tetra-ethyl-lead was 2750 tons, or 5,500,000 pounds.

The Lead Industries Association advises that during 1927, the first year during which a gasoline containing tetra-ethyl lead was fully exploited throughout the United States, a little over 300,000,000 gallons was sold. This accounted for about 1,300,000 pounds of lead. An average of two grams of lead is used per gallon of gasoline. In the following year, 1928, about 600,000,000 gallons of leaded gasoline was marketed, and about 2,700,000 pounds of lead was used.

Conservative estimates based on sales earlier in 1929, place consumption of leaded gasoline at about 1,250,000,000 gallons, which would require about 5,500,000 pounds of metallic lead.

Compared to other industrial outlets for lead, this amount is not large but it represents an entirely new outlet for the metal that is becoming increasingly important and one that is not likely to be replaced by substitutes, as tetra-ethyl lead proved the most satisfactory of 33,000 chemical compounds tested in the development of a practical anti-knock compound. The largest needs for lead are for storage batteries, cable covering, and white lead and in the order named.

Gas Oil Results From Reduced Crude Cracking Stock

By C. H. LEACH

ONE of the advantages claimed by Dr. Karl Bender for the "Carburol Cracking Process" in the November issue of THE REFINER AND NATURAL GASOLINE MANUFACTURER, is the possibility of removing a part of the heavy ends which would cause coke formation from the charging stock before it enters the cracking coils. In the diagram,* accompanying his article, two sources of cracking stock are shown—one part of the feed is mixed with the hot oil from the furnace after the reducing valve, the remainder is mixed with the recycle stock and then passed through trimming coils and heat exchangers to the cracking coils in the usual manner. That portion of the fresh feed which is mixed with the hot oil receives a valuable pre-treatment. The excess heat of the cracked oil vaporizes the lighter portions, leaving the heavy residue to be removed with the tar from the cracking process. The clean light fractions are condensed and returned to the system with the recycle stock.

Readers of this paper may be interested in a process used in an American refinery for the cracking of reduced crude, without excessive coke production or other difficulties usually encountered in attempting to crack a residual stock. Figure 1 shows the flow sheet of the process. By means of high temperature heat exchangers the entire raw feed is pre-heated from 70°F. to 750°F. with heat that was formerly wasted. It is then charged into the vaporizer where it comes in contact with the vapors from cracking coils at 910°F. A light cracking of the heavy ends takes place and the entire reduced crude, with the exception of the asphaltic residue, is vaporized to be condensed in the vapor heat exchangers with the recycle stock. In this way the heavy asphaltic ends in the reduced crude, which would produce carbon in the coils, are separated without entering the cracking furnace, and the total feed to the coils is clean gas oil and recycle stock.

This method of operation, which sends only clean stock to the coils instead of the original reduced crude, has increased the maximum safe capacity over 60 per cent, and the length of the runs from 10 days to over 60 days at the maximum rate of conversion. All the operating possibilities of a high priced gas oil are secured with the cheapest cracking stock.

It should be emphasized that with the grade of reduced crude used in this refinery it is the last 50 degrees of preheat added to the fresh feed which makes the process possible. If the reduced crude were to enter the vaporizer at 700°F. instead of 750°F., valuable cracking stock would be carried off in the tar.

Figure 2 is the same type of installation as shown in Figure 1, as it would be built for a new plant. A single bubble tower is used and high pressure exchangers are employed to cool the tower. Liquid to liquid exchangers are also added to preheat the gas oil total feed by means of the tar from the vaporizers, raising the temperature of the feed entering the cracking furnace from 605°F. to 650°F. A steam stripper may be used if desired, but it is not necessary to remove the light gas oil as it can be successfully cracked in this process.

The possibilities of saving with high temperature, high pressure, heat exchangers have only recently been recognized. The direct saving in fuel is often the smallest of the advantages obtained. The capacity of the whole plant, including the expensive cracking coils, is stepped up and often a completely new method of operation, as in the case described above, is made possible.

*Refiner and Natural Gasoline Manufacturer, page 57, November, 1929.

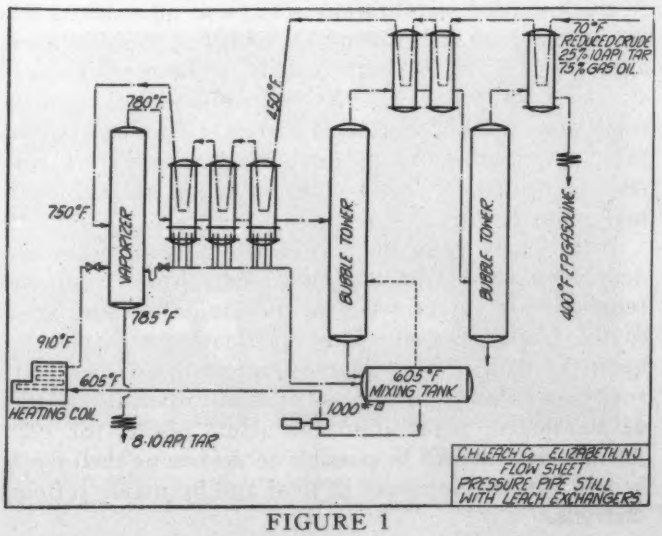


FIGURE 1

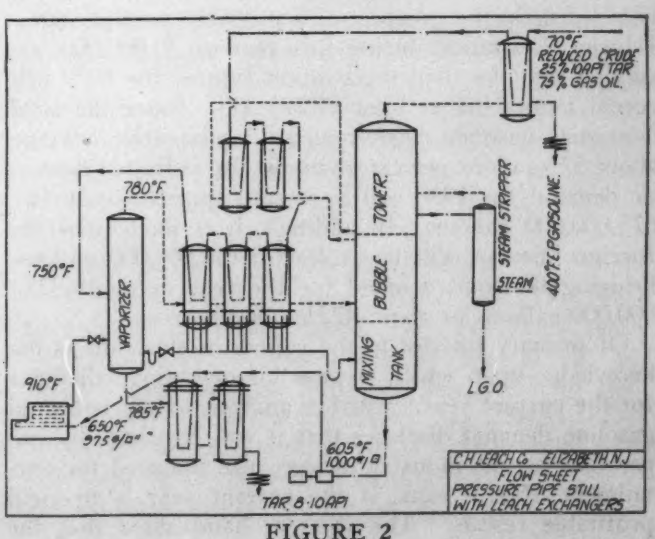


FIGURE 2

Survey Shows Need for Curtailment Of Refinery Runs

By H. J. STRUTH
Staff Economist

ALTHOUGH it is still too early to obtain an accurate index of the probable demand for gasoline during 1930, lacking final and complete data for 1929, a preliminary survey shows that refinery runs must be maintained at a rate not to exceed those of 1929. A careful check of all data available at this time reveals a decidedly good year ahead for the industry, provided that immediate action is taken to concertedly control the volume of crude processed by the refiners. While there is positive evidence that the demand for gasoline and other refined products will again show a substantial increase, it is apparent that the rate of increase in gasoline demand will not be as great as last year's results indicated. However, a careful check of the opinions of leading motor car manufacturers, combined with other influencing data, seems to offer the assurance that the demand for gasoline during the current year will exceed that of last year by approximately 7.7 per cent. This figure contemplates a substantial increase in the demand of both domestic and foreign gasoline consumers, representing the total requirements from the refiner, natural gasoline manufacturer and including imported gasoline.

Last year the writer estimated the total gasoline demand at 438 million barrels, which, up to November 30, proved to have been remarkably close to the actual results reported by the United States Bureau of Mines. As a matter of fact, the cumulative estimate for the 11 months ending November 30, 1929, aggregated 403 million barrels, while the actual consumption reported by the Bureau of Mines aggregated about 401 million barrels. It is therefore apparent that the total demand for 1929 will be approximately 438 million barrels. This year the preliminary survey discloses that the total gasoline demand will probably aggregate 472 million barrels, or an increase of 7.7 per cent. This conclusion is based upon the prospect of a probable average motor vehicle registration during this year of 29,000,000, assuming that the final registration figures for 1929 will reveal a total of at least 27,775,000. Since the total domestic gasoline requirements apparently average about 575 gallons per car annually, the indicated domestic demand for 1930 will aggregate approximately 16,675,000,000 gallons. In addition, it is likely that the foreign demand will be at least 3,150,000,000 gallons, bringing the total demand for the year up to 19,825,000,000 gallons, or about 472 million barrels.

Of primary interest to the refiner at this time is the knowledge upon which to base his operating schedules for the current year. Further analysis of the indicated gasoline demand discloses that it will be decidedly imperative for the industry to recognize the need for curtailment of still runs, if the current year is to yield profitable results. The facts at hand show that the refining industry will be obliged to maintain still run schedules within the limits established during 1929, or suffer the consequences of further over-production. The accompanying table sums up the situation concisely and presents some idea of the maximum quantity of gasoline required through the distillation of crude. While this data may be subjected to slight changes, it shows the approximate "dead line" that is expected to be conducive to a sound economic program of operation for this year.

PRELIMINARY SURVEY OF 1930 GASOLINE REQUIREMENTS

	Million Barrels
Domestic Gasoline Demand	397
Foreign Gasoline Demand	75
Total Indicated Demand	472
Natural Gasoline Content	55
Net Gasoline from Crude	417
Imported Gasoline	15
Net Gasoline Required from Refineries	402
Indicated Excess Gasoline Stock	6
Maximum Production Required	396

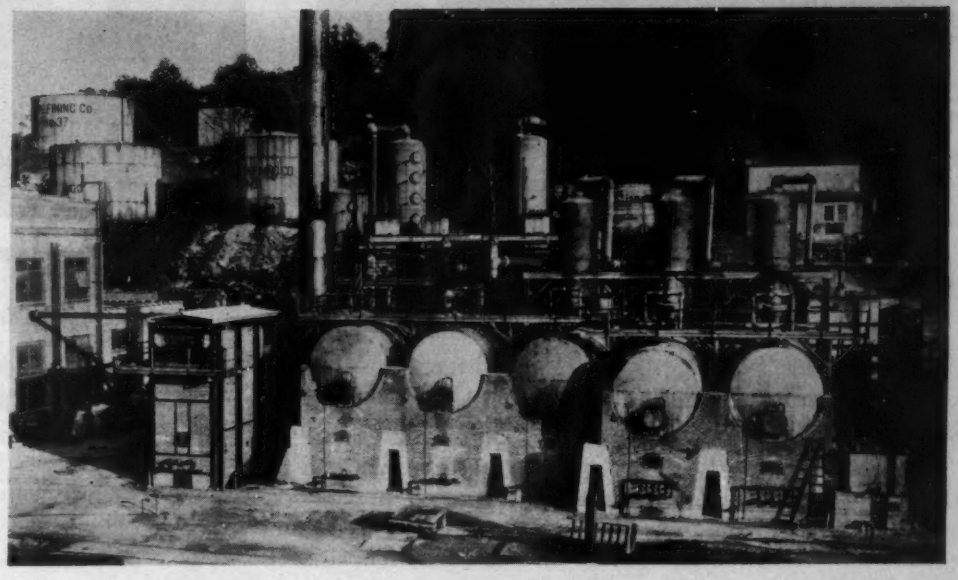
A conservative estimate of gasoline recovery during this year contemplates an average yield of about 40 per cent, which, on the basis of maximum amount of gasoline required this year indicates a total crude throughput by United States refineries of approximately 990,000,000 barrels. This represents a daily average of 2,712,000 barrels, and compares with an actual daily average for last year of 2,716,000 barrels. It is therefore evident that the industry must maintain still run schedules at or slightly below the levels of last year, if much needed stabilization is to be at all realized this year. Runs to stills during December apparently averaged about 2,550,000 barrels daily, while a preliminary standard for January, 1930, contemplates a maximum total run of about 2,382,000 barrels. This data shows that, at present rates of processing, refiners are consuming at least 168,000 barrels per day in excess of normal requirements.

In an early issue the writer will present additional detailed data showing the indicated normal crude run requirements of refineries in the major refining areas of the United States. This information will be based upon the data presented here, subject to any necessary revisions entailed by receipt of final, official statistics of automotive registration and actual results for 1929. At that time, it will be possible to determine the monthly still run requirements in total and by major refining districts.

Continuous Operation of Both Shell And Tube Stills at Elk Plant

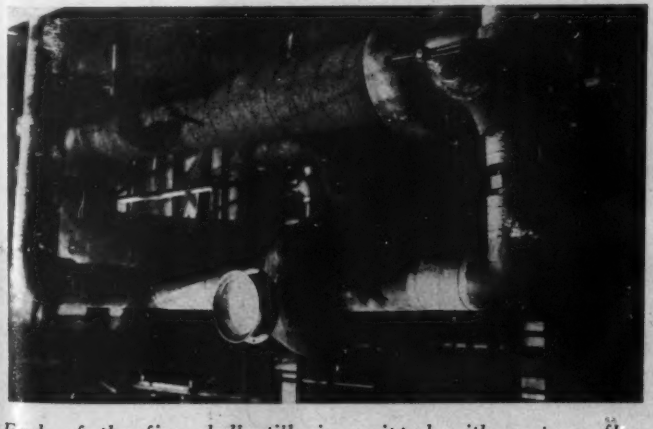
By GEORGE REID
Associate Editor

PENNSYLVANIA grade crude oil is processed at the Elk Refining Company's Falling Rock, West Virginia, plant through a continuous system incorporating both shell still and tube still equipment in one unit. The first improvement in plant operating facilities included the installation of tube still and bubble tower equipment. This was followed shortly by the addition of more bubble towers inserted farther down the line in the still battery which permits the distillation of overhead streams of pressable wax distillate and the continuous production of cylinder stock. Further improvement work was completed in the wax plant, the Sharples centrifuging plant and power house, all of which contributed to modernizing the refinery to the end that better economy of operation and greater efficiency is secured.



Skimming plant at Elk Refining Company's Falling Rock, West Virginia, refinery. Four streams of gasoline are removed from the first tower. Cylinder stock is made continuously and pressable wax distillates are taken overhead from the last three towers

Unlike most refineries in the Pennsylvania district this plant burns no coal but fires all furnaces with natural gas, which is much easier to control by automatic regulation and which is, of course, much cleaner in its use. However, the power plant, which consists of three Oil City water tube boilers, gas fired with DuQuesne combustion units, is also equipped with furnaces designed for the consumption of coal as fuel by the installation of automatic stokers.



Each of the five shell stills is equipped with a steam flow controller regulating and measuring and indicating steam flow to the still in pounds per hour

Two boilers are required to provide sufficient steam for plant operation, the third boiler being stand-by equipment. The power plant is modern in every respect, equipped with all required control instruments, and housed in a large brick and steel building with ample space provided for the installation of additional steam generating equipment if further enlargement of the refinery is needed.

In the continuous distillation department one Foster tube still with four-inch tubes and five shell stills are employed. Fractionation of the various cuts is secured by means of three bubble towers designed by and installed under the supervision of H. S. Bell, and three additional bubble towers on the last three stills in the series designed by Dr. E. H. Leslie. Some light streams are again split after leaving the towers in Leach Fracto Condensers.

DISTILLATION PROCESS

Crude oil enters the system through the Leach exchanger-condensers and through the Foster tube still. In this equipment the oil is heated to about 375°F. It discharges from the pipe still into the bottom of the evaporator where the gasoline vapors are flashed from the crude to pass through a series of bubble trays and into the next bubble type fractionating tower.

The overhead stream of vapors from the gasoline

Interior of refrigeration plant, consisting of two units, one being for Sharples dewaxing plant and the other for chilling neutrals for filter pressing. All pumps and machinery are electric driven direct connected to motors, thus eliminating all belts

Interior of wax packing plant showing wax chipper in operation. This department, like the wax plant, centrifuge plant and other departments, is finished in white enamel and trimmed with dark green—and kept clean

tower is partially condensed in a Leach Fracto condenser yielding two light streams, the lighter being about 80 gravity and the heavier being a stream with an end point of about 300°F. Another stream of light gasoline is removed from the side of the tower which has an end point of about 375°F. From the bottom of the gasoline tower a stream of 410 end point gasoline is removed. In this manner the gasoline or naphtha fraction of the gasoline content of the crude is split into four different fractions which may be blended back together if necessary at the receiving house or after reaching run down storage, or they may be utilized as they are produced for rubber solvents, painters or dry cleaners naphthas or other solvents. Such is usually the case as the company specializes in the preparation of special naphtha products to meet specifications of various buyers. With four fractions of the type mentioned and stabilized natural gasoline it is possible to produce a wide variety of special products. Further equipment for the preparation of close cuts or special naphthas of narrow boiling range is found in the rerun department where the unit is equipped with a large bubble tower designed especially for such work.

The crude oil partially topped in the tube still and evaporator operation flows by gravity from the separator tower into No. 1 shell still where a stream of 45 gravity Pennsylvania grade kerosene is removed. In No. 2 shell still the gas oil or "fuel oil" is vaporized and removed. Both these streams are fractionated to desired specifications. Each tower is regulated as to operating temperature by automatic control instruments which regulate the operation of small "trim" pumps recycling of the tops of the towers.

The third still yields a stream of light wax distillate which is fractionated in a Leslie bubble tower of the type employed on stills Nos. 4 and 5. As the crude flow

Rerun department where stocks are reduced after centrifuging and where many of the special naphtha products are prepared through the bubble tower shown

moves from the third still it passes into stills 4 and 5 alternately. In other words, while still No. 4 is reducing its charge, still No. 5 is being filled with oil to be ready for reduction when still No. 4 is finished. This method of operation gives practically continuous production of cylinder stock and wax distillate. Wax distillate removed from these stills through the Leslie towers is then ready for the presses without any further processing. The cylinder stock is taken to the bright stock plant after cooling.

STEAM CONTROL

An interesting feature in connection with the shell still operation is found in the use of Stream Flow Controllers on each of the five stills. These instruments are of the Campbell type and are designed to give the operator accurate control of the volume of steam going into the still and to record or indicate that volume in pounds per hour.

Through the use of such flow controllers on the stills the steam is injected into the still at constant and uniform rate. It is not a meter since a meter merely records flow which is controlled by other means, although it controls and records steam flow at the desired rate, thus taking the guess work out of steam injection into low pressure vessels used in process work. Such a practice results in direct savings in steam, fuel and labor, and eliminates the necessity of guessing at the amount of steam to be used in a given still or process. Further such control instruments are helpful to the accounting department in determining process costs. Installations such as this are becoming of widespread application in the refining industry and especially among the Eastern refiners where process work in the preparation of lubricants require much steam and therefore accurate control.

The cylinder stock is taken direct to the filter house for filtering to color prior to dewaxing. The filter house is being enlarged from 16 to 20 percolating filters. It is designed so that all neutrals are filtered to one side of the building and bright stock filteration on the other side. In a separate brick building nearby the fullers earth is burned for re-use. This department is located as far from the remainder of the plant as the site will permit for the purpose of reduction of fire hazard.

Filtered cylinder stock is taken from the filter house to mixing tanks, blended with 60 percent of naphtha, chilled, and centrifuges in the Sharples plant. There are five super-centrifuge machines in operation here, with space provided for the installation of 10 more. This plant is designed for the convenience of operators as well as for efficiency of operation. The center portion of the floor is covered with creosote blocks. Ceiling and upper walls are painted white and 14 drop lights are provided at intervals throughout the room. A departure from ordinary usage is found in the adoption of Ivory Sani Onyx for covering the walls of the centrifuge plant up to a height of about six feet. This material is similar to that used by restaurants for table tops, etc. It adds greatly to the appearance of the plant but its chief advantage lies in the fact that it is very easily kept spotlessly white.

WAX PLANT

After dewaxing the bright stock and petrolatum are taken to reducing stills where the naphtha is removed. The bright stock is filtered again if color specifications necessitate such treatment.

The wax plant is a complete Carbondale refrigeration system consisting of two units, one of which is employed in chilling bright stock for the centrifuging operation, while the second unit is utilized in chilling and pressing neutrals. All of the machinery, pumps, and compressors are electric driven and direct connected which entirely eliminates the use of belts in this department. Manager R. D. Lowe of the Elk Refining Company, and Superintendent E. A. Anderson, in charge of the refinery, insist upon cleanliness in the operation of all departments of the plant. In the wax plant, chilling room, press rooms, and wax packing plant, spotlessness is the rule. These buildings are painted inside with two coats of flat white and then covered with a coat of white enamel, with a trimming of green. The buildings are constructed of brick and steel with concrete floors.

The wax is passed through the chipper machine and packed in barrels and sacks. Much of the sacked wax is shipped to South America where the legal load for man or mule is 175 pounds.

The new Carbondale wax presses are equipped with the latest type of oil drain and wax conveyor which are designed so that when the pressing operation is completed and the oil draining is done, the oil trough is moved to one side by means of a lever. This exposes the wax conveyor and removing trough, which moves the wax away in the opposite direction of the oil flow. This eliminates any chance of dumped wax being accidentally mixed with the pressed oil, and effecting the pour test of the lubricants.

The Elk Refining Company is processing Pennsylvania grade crude oil at the rate of 2200 barrels per day. In addition to its production of gasoline, a variety of special naphthas, furnace or fuel oil, a complete line of lubricating oils is manufactured, as well as wax. A small gasoline recovery plant is operated which employs a compressor pulling a slight vacuum on the receiving house and light gasoline storage tanks. These vapors are discharged through a small absorber through which naphtha is circulated with the result that an additional yield of gasoline is recovered which averages about 800 gallons per day. Since the plant is located 17 miles north of Charleston on the Elk River the company maintains a camp for its employees near the plant. Every precaution is taken to reduce fire hazards, since the plant is located in a small valley along the river and surrounded by hills. Its fire record is excellent since it has experienced but four small and unimportant fires in 15 years of operation.

Low Cold Test Oils by Direct Ammonia Expansion

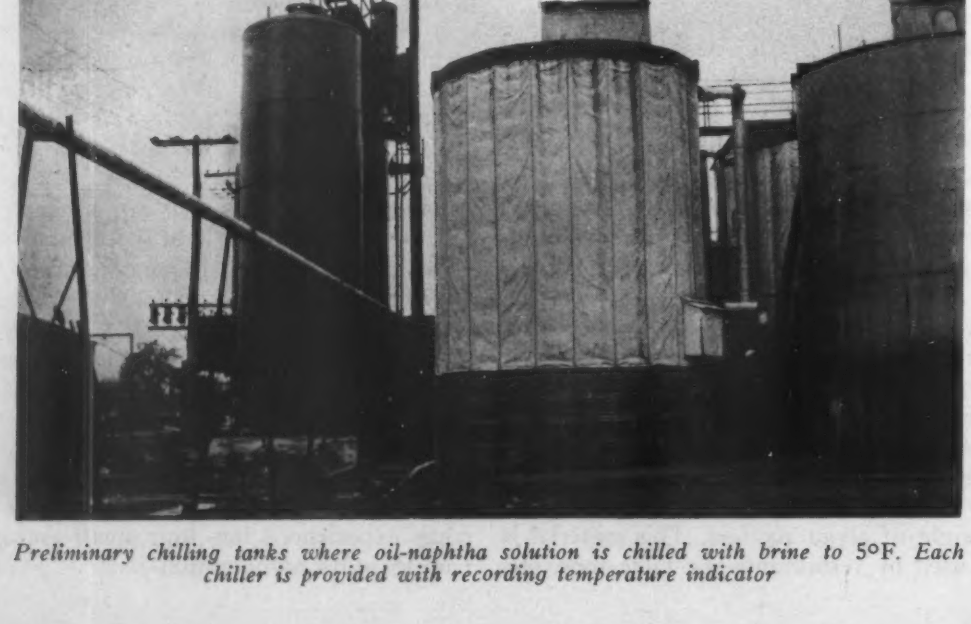
By GEORGE REID
Associate Editor

CHILLING of lubricant stocks to the low temperature of —40°F. for the production of finished oils having a zero cold test, which has been investigated extensively during the past two years or more, is now becoming widespread in its application. In the Pennsylvania and East Coast refining districts, where paraffin base or Pennsylvania grade crude is refined, there are a large number of installations of the direct expansion ammonia system either recently placed in service or under construction. Likewise in the Mid-Continent area there are a great number of similar plants in operation or building, for the popular demand for low cold test lubricants has become so insistent that manufacturers must bear this additional expense of processing in order to successfully compete in the lubricating oil markets.

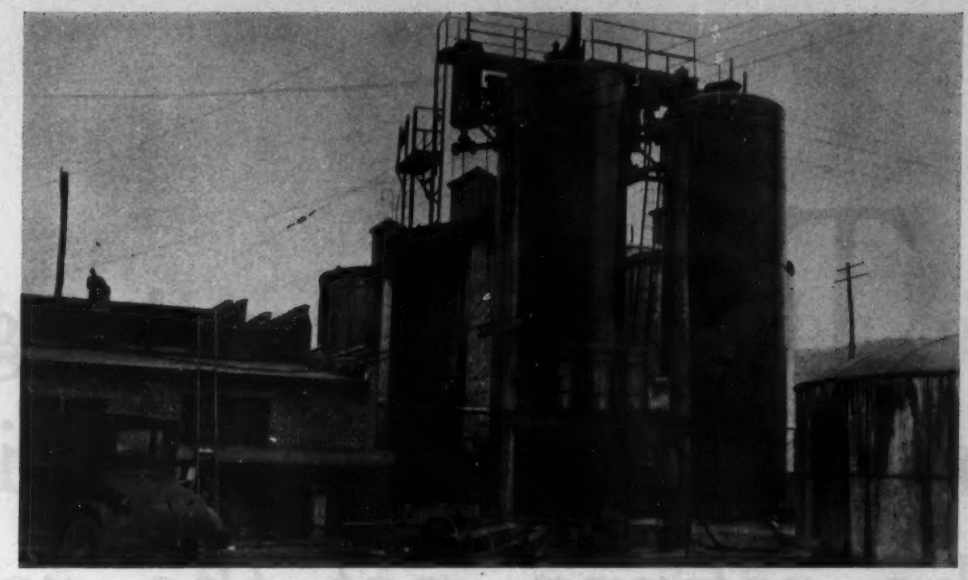
Bradford Oil Refining Company, Bradford, Pennsylvania, is numbered among those Pennsylvania refiners who are employing direct expansion of ammonia for chilling to very low temperature. In this system the temperature of the ammounia reaches —60°, which reduces the temperature of the oil-naphtha solution being treated to —40°F. The refinery operated by this company employs tube still distillation or heating and circulation of the heated crude through a shell still type separator and treats the oil while in this process with contact clay, followed by filtration, chilling and centrifugal dewaxing. The details of this system of operation were presented in THE REFINER AND NATURAL GASOLINE MANUFACTURER, issue of November, 1927, page 49. The new direct expansion ammonia system augments the previously employed chilling system where stocks were chilled to produce finished oils of normal cold test for Pennsylvania lubricants, chilling by means of brine circulation to about 10 degrees below zero.

The old chilling system remains in use. The equipment consists of an 85-ton York refrigerating plant, the compressor being driven by a 225 horsepower Burke synchronous electric motor. Ammonia in this system is kept in a closed coil system and chills the conventional brine solution in the shell of the condenser. The cold brine is then circulated by motor-driven centrifugal pumps through coils in the three chilling tanks.

Each of the three chilling tanks are heavily insulated and weather-proofed with roofing paper. There is a current practice in the Pennsylvania area which involves the insulation of tanks with the usual materials, to be followed by a weather-proofing wall of tile which protects the insulating material from both accidental damage and natural deterioration for many years. Each of the three tanks employed in this system is equipped with a mechanical stirring device driven by a shaft extending from the motor drive at the tank top. The agitators are located near the bottom of the chiller tanks. The solution of 65 per cent naphtha and 35 per cent oil is charged to the chillers at 100° and slowly chilled to about —5° at this point. Each chiller is provided with an American indicating temperature recorder for the guidance of the operators. Such instruments



Preliminary chilling tanks where oil-naphtha solution is chilled with brine to 5°F. Each chiller is provided with recording temperature indicator



New chilling equipment under construction at Bradford Oil Refining Company's plant, Bradford, Pennsylvania, where oil is chilled to 40° below zero in the preparation of bright stock

are essential to uniform results in dewaxing as the temperature-time factor is of great importance in crystallization work.

NEW SYSTEM

The new low temperature system consists of two additional chilling tanks 10 feet in diameter and 30 feet high. They are operated by the batch system, as are the preliminary chillers. Ammonia is discharged into a bottom header from where it is distributed through a series of coils to converge again in an upper header and pass into an ammonia accumulator. From this point it is removed under a slight vacuum by one of the new York vertical compressors, which are 25-ton rating and electrically driven. These additional compressors act as boosters and discharge the ammonia to the larger compressor previously described. Ammonia from the larger compressor goes to a condenser, a surge tank, and is expanded back into the bottom header in the chilling tank.

Lines and fittings conveying ammonia in the circuit are heavy duty type and leak proof, in order to eliminate the loss of ammonia. The chilling coils inside of the chiller tanks are 22 feet three inches in length. There are three coils in six sections, the tubes being two-inch. Six-inch headers are provided at top and bottom. In each chilling tank there are four coil sections having 22 tubes each and two sections consisting of 11 tubes each, or a total of 110 tubes in the coil system per chiller.

Each of the new chilling tanks are provided with a mechanical agitator which is electrically driven. The motor is placed in a weather-proof housing outside of the tank and near the bottom. By means of suitable gears this motor revolves the large spider type agitator paddles in constant horizontal movement. This prevents the accumulation of wax at the bottom of the chiller and keeps it in suspension.

Other systems of direct expansion of ammonia for chilling provide an expansion tank near the bottom of the chiller from which the ammonia vapor flows upward and into the cooling coils inside of the tank. In this system, however, the ammonia is discharged directly into a body of liquid ammonia held in the coils, and the expansion chamber or accumulator is provided at the top of the chilling tank. This accumulator is 30 inches in diameter by seven feet five inches in height. The booster pumps or compressor pull a slight vacuum on this accumulator and boost the vapors over into the large compressor. From this point the compressed ammonia is discharged to primary and secondary condensers, then to a surge or ammonia storage tank of small dimensions, from which point it passes directly into the six-inch bottom header which is filled with liquid ammonia. The chillers are provided with conical bottoms.

After a batch of oil-solvent mixture is chilled to about five degrees below zero by means of the cold brine solution in the old cooling equipment, it is picked up by an electric driven Kinney pump and transferred to the new low temperature chillers. Here the ammonia temperature of —60°F. chills the solution to —40°F.

After chilling to this low temperature the solution is taken directly to the centrifugal dewaxing plant and passed through the 10 Sharples super-centrifuges. The petrolatum is taken to a reducing still and the naphtha employed for solution is distilled for further blending. This petrolatum is usually burned as fuel unless the market appreciates sufficiently to warrant its preparation for sale. The dewaxed oil is likewise taken to a reducing still where the naphtha is reclaimed, after which processing the oil is transferred to the barreling house ready for shipment.

In the application of this process to Pennsylvania crude lubricant fractions, or to lubricating oil fractions from mixed base crudes, the principal advantage gained through the additional expenditure for equipment and processing lies in the fact that the manufacturer is permitted to produce a lubricant with as low a cold or pour test as that produced from any other crude. A greater degree of fluidity at lowered temperature is secured without impairment of any other characteristics peculiar to the mixed base or paraffin base crudes.

The Dubbs cracking process operates to suit the refiner, not the refiner to suit the process

It will crack efficiently residues, by-products or slops that can serve no other useful purpose except to yield, through cracking, a high percentage of good gaso-

line It can crack gas oil or other light fractions, too, if sales conditions make that desirable

The Dubbs process will do these things at a bigger profit to the refiner than any other method of operation

Universal Oil Products Co
Chicago, Illinois

Dubbs Cracking Process
Owner and Licensor

Diphenyl Characteristics Determined

THE properties of diphenyl is in accord with those of other aromatic hydrocarbons. The chief application of diphenyl has been as a material for high temperature vapor phase heat transfer, as it is employed by the Indian Refining Company, Lawrenceville, Illinois, in the operation of the Govers Process for the manufacture of lubricants. It is manufactured under large scale production by the Federal Phosphorus Company, Birmingham, Alabama, and this achievement has taken it out of the class of laboratory curiosities and placed it on the market in carload lots at a price that makes it available for the preparation of many promising derivitives.

Diphenyl with its low vapor pressure and high critical temperature has advantages over steam as a heating medium which are obvious. It has a relatively high heat of vaporization, high molal heat capacity, and for all practical purposes it may be considered stable at high temperature. These characteristics and other properties were determined by John Chipman and S. B. Peltier, of the department of chemistry, Georgia School of Technology, Atlanta, Georgia, and so reported in Industrial and Engineering Chemistry, issue of November, 1929.

VARIOUS APPLICATIONS

Diphenyl, which is made from benzene by a pyrolytic process, has a melting point of 69.0°C., and a boiling point of 254.9°C., when pure, according to the manufacturers. It is insoluble in water but soluble in the usual organic solvents.

Chloronated diphenyl has many applications and may be employed for various purposes, in its various grades. One product exhibits marked solvent properties and a high range between freezing and boiling points indicates its application for extracting and crystallizing, and as an introfier in the penetration of impregnating materials. Other grades may be employed as an ingredient of a new synthetic resin or platic, and as a substitute or modifier for certain gums, resins and adhesives, or as a varnish gum, an ingredient of condensation products, a plasticizer, an insulating material, a flame-proofing medium, water-proofing agent, or a binder for plastic materials. These are but some of the applications of diphynl derivitives.

Chipman and Peltier found the boiling point of diphenyl to be 254.05°C. at 741 mm, which corrected to 255.25°C. at 760 mm. They determined the vapor pressure of diphenyl at round temperatures to be as follows:

VAPOR PRESSURES OF DIPHENYL AT ROUND TEMPERATURES

Temperature ° C.	Pressure Mm.	Temperature ° F.	Pressure Lbs. per sq. in.
(70)	0.82	(200)	0.060
(100)	4.35	(250)	0.227
(130)	17.2	(300)	0.701
160	54.2	350	1.832
180	105.3	400	4.197
200	191.5	450	8.638
220	329.1	500	16.29
240	537.8	550	28.54
260	842.2	600	47.01
280	1269	(650)	73.55
300	1851	(700)	110.1
320	2621	(750)	158.6
(340)	3614	(800)	221.0
(360)	4870		
(380)	6425		
(400)	8315		

According to the authors, "Apparently the only data in the literature on the vapor pressure of diphenyl are those of Jaquerod and Wassmer Ber. 37-2531 (1904.)

BOILING POINTS

These investigators measured the boiling points of naphthalene, diphenyl, and benzophenone under pressures from 250 to 800 mm., using a hydrogen thermometer. The boiling points of naphthalene and benzophenone have since been adopted as secondary points on the I. C. T. scale. These points are, respectively, 0.28° and 0.46°C. higher than those recorded by Jaquerod and Wassmer. If we assume that their themmometer was correct at 100°C. we find that the correction to be applied to their data is a linear function of the temperature, and by interpolation the correction at 254.93°C. is 0.36°C. With this correction their boiling point of diphenyl is 255.29°C., in excellent agreement with the writers' value, 255.25°C. Similarly corrected, all of their data are in fair agreement with those of the writers."

For additional information regarding density of liquid and vapor, heat or vaporization, entropy of vaporization, and form of vapor pressure curve, the reader is referred to the work of Chipman and Peltier, and to the article by the writer in THE REFINER AND NATURAL GASOLINE MANUFACTURER, issue of October, 1929, pages 63, 64, 65, wherein the employment of diphenyl as an indirect heating medium and the characteristics of liquid and vapor, heat or vaporization, entropy of vaporization, and form of vapor pressure curve, the reader is Heating Medium."

Welding Plays Important Part in Refinery Maintenance

THE ever increasing demand for gasoline has completely changed refinery methods of a few years ago. Formerly the crude stills did not give gasoline directly, but rather a mixture of light oils from which the gasoline had to be separated by subsequent treatment. In addition, the amount of gasoline obtainable from a given crude was limited to the amount originally contained in the crude.

As the demand for gasoline increased better refining methods were sought. The solution to the problem was found in the introduction of the cracking process. With this process the heavier fractions such as gas oil or fuel oil are heated under pressure in special furnaces or stills in such a way that the heavier compounds are chemically changed and broken down or "cracked" into lighter ones, thereby producing an additional amount of gasoline.

The present refinery practice is continuous distillation with direct separation of the desired fractions, thus eliminating redistillation. Pipe stills are replacing the older shell stills and the bubble tower or fractionating column has been adapted from the chemical industries to give clean cut separation of fractions in a single distillation. All this means that refinery equipment has suddenly become more complicated. And in developing these new types of stills and fractionating equipment, each refinery (or at least each company), has worked out its own ideas. This has meant much fabrication of intricate equipment right at the refinery. In this work welding has been of incalcuable assistance.

Indeed the efficiency of welding is evident from the moment that the designing engineer begins to work out his ideas in practical form. He can proceed to design the various parts as they should be, unhampered by the limitations of other construction methods. In the drafting room, the simplicity of the welded design speeds up the drawings and saves valuable time.

When it comes to construction, it will be found that practically the entire equipment can be built up from plate and pipe. Time lost through delays in obtaining special parts is reduced to a minimum.

Accordingly the new plant goes up in record time. Welded joints being leak-proof from the moment they are made, the plant can be quickly placed in operation without wasting any time in caulkink seams.

Later, when repairs or alterations become necessary, the cutting and welding equipment stands ready to do the work quickly and thoroughly.

Even more important in the present trend of development is the fact that welding makes possible the successful operation of designs that could not possibly be constructed by other methods. For example: without welding, the mere idea of operating a whole still system within a few millimeters of absolute vacuum would seem preposterous.

Unfortunately many of these new developments in refinery practice represent such radical departures from conventional practice that details are withheld pending action on patent applications. However, ample evidence of the important part that welding is playing will be found in the statement made by the superintendent of a large Eastern refinery that heir mos modern distilling unit could not possibly have been built without welding.

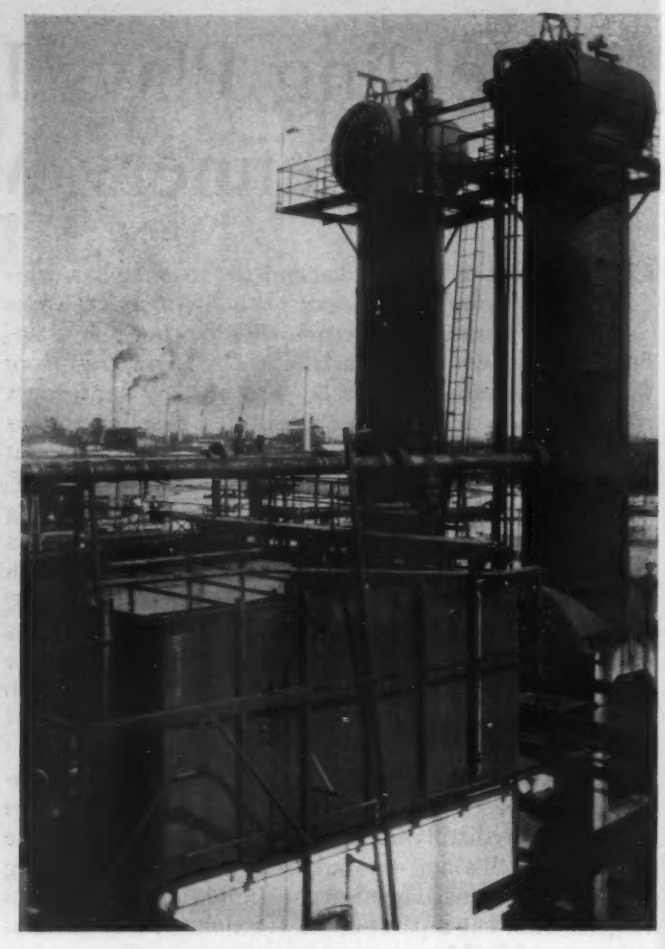
To obtain the maximum benefit from welding, attention must be given to organization for welding. Obviously only general principles can be stated here, as the application to any particular refinery will depend upon size, method of organizations and other individual factors.

SEPARATE DEPARTMENTS

In a large refinery, there may be several welding or-

Headers of various types are easily fabricated by means of the welder's tools

Overhead lines supported by welded stanchions



Fractionating tower with welded joints

ganizations connected with separate departments, somewhat as follows:

Shop department—The central welding shop, which forms a part of this department, is equipped to do all kinds of welding and cutting. Practically all of the work is done on order from other shops and departments. Here is concentrated all work that can be done in a shop as distinct from work that must be done on equipment in place or under erection.

Construction department—This department usually handles a large amount of the welding and cutting done outside of the central shop. But its welding organization can not function to full advantage unless the designing and drafting departments fully understand the possibilities of welded construction and specify it on their drawings. Closer cooperation between designers and experienced welders will result in extended application of welding.

Maintenance department—Repair and maintenance of a modern refinery offer splendid opportunities for high-grade welding and cutting. The operators in this department should be experienced men of marked ability and ingenuity, for they are called upon to solve many perplexing problems. Equipment that has been in operation is not as accessible as it was during construction. Besides, it may be covered with oil or filled with flammable vapors. Accordingly, in maintenance work, particular attention must be given to safety precautions.

All equipment should be provided with steam connections of ample size, so that it can be thoroughly steamed out before any repairs are made. The time required for steaming obviously varies with the equipment, the bubble tower with its numerous trays probably presenting the greatest problem because of the opportunities for the formation of gas pockets. If the tower is shut down late in the afternoon and steamed all night, a test would probably prove it clear in the morning.

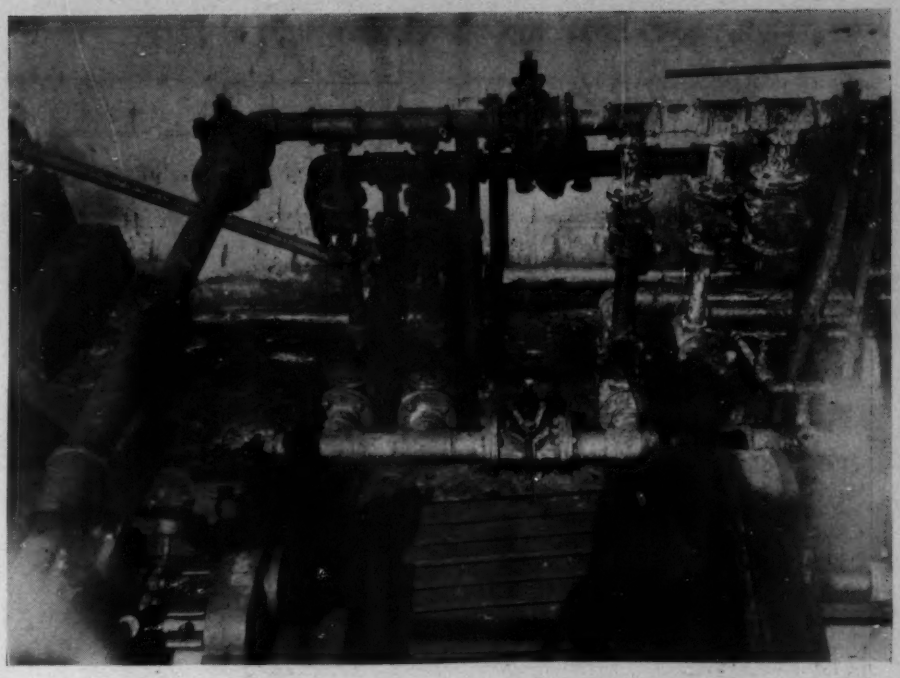
The decision as to when it is safe to enter the equipment and start repair should be made by someone in authority. At one large refinery the maintenance superintendent personally inspects the equipment. There has been recently developed a device known as a combustible gas indicator which is particularly valuable in making such inspections to determine when it is safe to make repairs. With this instrument it is possible to determine instantly the presence of a wide variety of flammable gases and vapors. A direct and accurate reading is given on a meter scale. Especially for use in the petroleum industry, the meter scale is divided into a white section and a red section. If the meter needle comes to rest anywhere in the red section an atmosphere containing 0.2 per cent. or more of combustible gas (expressed as pentane vapor) is indicated. This means that the atmosphere is unsafe to breathe without gas masks and is unsafe for any work that requires heat or fire or is liable to breathe without without gas masks.

It should be noted that these safety precautions apply to repair work done in any way and not only to welding

and cutting. A sledge hammer and chisel are also productive of sparks.

RECLAMATION DEPARTMENT

The salvaging of scrap materials is an operation of considerable economic importance. Demolition proceeds rapidly with the cutting torch, and with careful planning many of the parts may be recovered in a form suitable for further use. Used pipe forms one of the most versatile of construction materials when welding and cutting are employed. Reclaimed pressure piping can be reused for low pressure service, while ordinary used pipe can be converted into an almost unlimited number of useful articles, such as handrails, stairways, ladders, and pipe supports, to mention but a few.



Acid sludge manifold with the valves bronze welded

A striking example of reclamation work was the conversion of obsolete refinery apparatus into gravity storage tanks for gasoline and oil. Due to the changes in production methods a certain oil refiner found that he had 40 large vessels on his hands for which there was no further use. They had served a long period of usefulness and were still in good condition. They were hammer-weled containers, 10 feet in diameter and 40 feet long. The plate was five-eighths-inch thick and perfectly sound.

It occurred to the management that if the nozzles and other connections could be removed and the openings closed successfully these containers could well be used elsewhere for gasoline or oil storage. To preserve the perfect tightness of the structure it was resolved to experiment with welding patches on one of the tanks in order to gauge the possibilities of the process for reclaiming the entire battery.

Welding of patches in steel vessels such as these presents some nice problems in expansion and contraction. The action of the metal under heating and cooling is something inevitable; so that instead of attempting to curb these irresistible forces, the thing to do is to make them work for the success of the weld rather than against it.

At this plant a large amount of welding had been done for several years, and the operators were quite proficient. However, they had not previously attempted work of this nature, so a service operator, furnished by a large oxygen manufacturer, was called upon to assist in welding the patches, in order to point out the special practices involved in this class of welding.

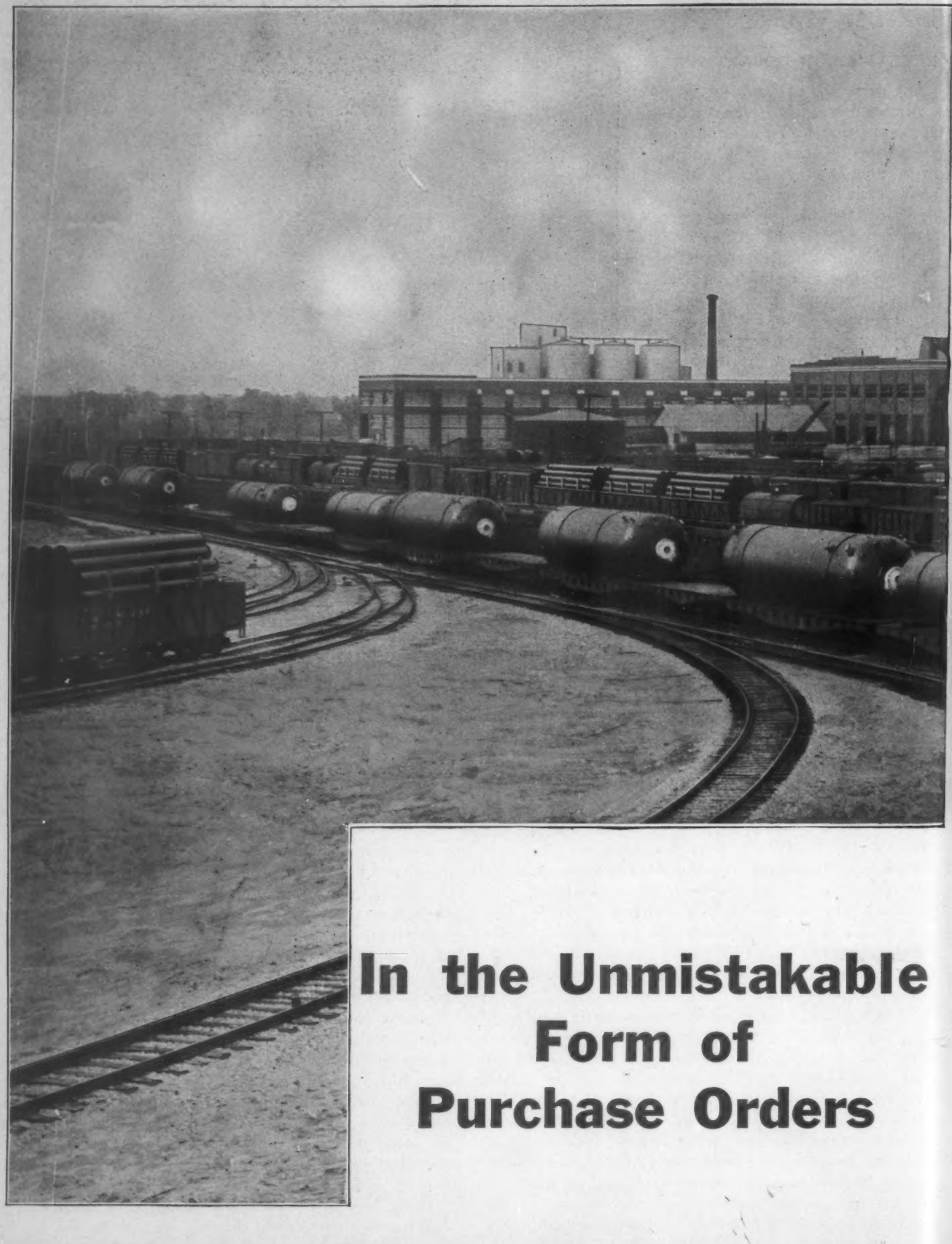
On the first job there were five patches to be placed, ranging in size from six inches to 34 inches diameter. The first step in the operation was the removal of the old connections which had been riveted to the plate. This was accomplished easily by cutting off the rivet heads.

After the rivets were backed out a row of holes remained, consequently a ring of steel had then to be cut before the patch could be placed. After a circle had been accurately scribed around the outside edge of the rivet holes, a cutting torch with a circle cutting attachment was brought into action and the cut was made in a continuous run, to produce a single ring, or large washer having the exact outside diameter of the desired patch. Then the edges of the shell plate were bevelled 45 degrees with a chipping hammer.

The next step was the preparation of the patches. For the two smaller patches of six-inch and nine-inch diameter, this was a relatively simple matter. In welding such patches it is desirable to dish the piece so that when the weld cools on completion the piece will flatten out, due to contraction. The dish was put in by bringing the patches to a white heat, and then placing them inside a standard three-foot dished tank head, after which they were hammered to the right shape.

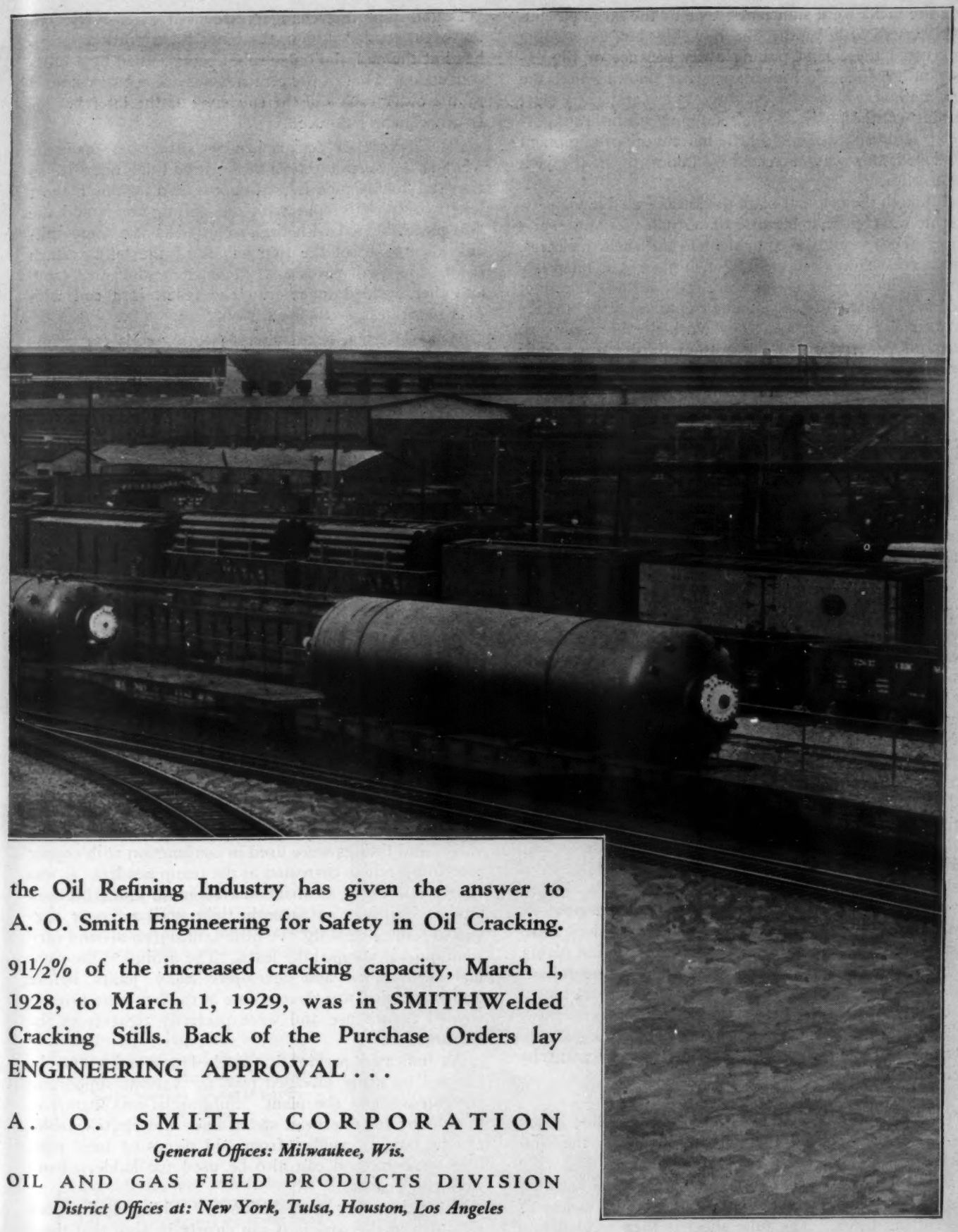
For such small diameters it was not necessary to allow for the radius of the shell. The larger ones, 24, 33, and 34 inches diameter, required more attention during preparation. A piece of firebox plate was cut square from the piece and then rolled to a five-foot radius, so as to correspond with the curvature of the shell. A piece of 1¼-inch plate was also rolled with a five-foot radius and a hole was cut in the center a little smaller than the patch. When sunk in the dirt of the boiler room floor so that the edges were flush, this served as a die for dishing the patches. As with the smaller sizes, this was done by heating in the forge and working with wooden mallets. After that the rolled and dished plates were cut to size with a circle cutting torch using the rings cut from the tank as templets. As soon as the edge was beveled with the cutting torch, the patch was ready for welding.

Great care was exercised in lining up before welding. A cross of timbers held in place with jacks was set on the inside to maintain alignment. In addition to that, four short bits of rod were welded to the edges of the pieces to lap over on the shell and forestall any dropping through if the interior shoring were to let go. After some experiment it was found that two diametrically



In the Unmistakable Form of Purchase Orders

SMITH*WELDED*



the Oil Refining Industry has given the answer to A. O. Smith Engineering for Safety in Oil Cracking.

91½% of the increased cracking capacity, March 1, 1928, to March 1, 1929, was in SMITHWelded Cracking Stills. Back of the Purchase Orders lay ENGINEERING APPROVAL . . .

A. O. SMITH CORPORATION
General Offices: Milwaukee, Wis.
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CRACKING STILLS

opposite tacks were sufficient. One of the large patches was started with 12 three-inch welds, but as welding progressed these kept pulling away because of the expansion strains. A little experience showed that the best method was to tack lightly twice and then start welding continuously around, stopping as little as possible. If during welding a little inaccuracy of alignment developed, this was corrected by taking up in the jack underneath.

Although the original plate thickness was five-eighths-inch, it was felt that because of normal wear one-half-inch patches would be equivalent to the shell thickness. Single vee welding on one-half-inch plate is at relatively easy task when proper procedure is employed. It cannot be done in a rapidly advancing ripple as on light plate or sheet. The weld must be "worked" thoroughly so that full penetration to the bottom of the vee can be secured. For plate of this thickness, one-quarter-inch welding rod is the proper size.

After each was welded the whole patch was brought to a red heat visible in daylight. This served to equalize all strains. Then the work was covered with asbestos paper for slow cooling. When cool, a hammer test was applied to the welds. No defects appeared in any of the work. So well were the strains distributed that the hammer test did not even cause the inevitable scale of oxide to peel from the welds.

EXPERIMENTAL EQUIPMENT

Refineries which try out their research ideas in semi-commercial plates have found that welding affords the ideal way of constructing such experimental equipment. Its perfect flexibility permits changes in design to be made at will, an extremely valuable feature in development work.

Even the smaller refineries without elaborate research facilities can economically try out new ideas in small-scale welded equipment.

In addition to the equipment made in their own shops, refineries buy many items from manufacturers who specialize in refinery equipment. The latter are also firm believers in welding, as the following partial list of welded equipment will indicate: steam stills, bubble towers, reflux towers, fractionators, dephlegmators, evaporators, condensers, heat exchangers, coolers, heaters, as well as equipment for gasoline absorption plants.

Turning now to more specific examples, the following have been selected with the idea of giving a glimpse of typical applications of welding in modern refineries.

Towers are typical of modern fractionating equipment constructed and kept in efficient operation by means of welding.

ABSORPTION TOWERS

The absorption towers used in natural gasoline plants are frequently welded throughout, including the supports.

Multitubular interchangers can be made by welding the tubes into a tube sheet cut from plate by means of the cutting torch. The tube sheet is then welded into the outside shell.

Welding permits the construction of interchangers with a number of different sized pipes nested one inside the other. In addition to being highly efficient, these interchangers present a very neat and compact appearance.

Double pipe interchangers are used extensively. In the usual welded design, the inner tubes form a return bend at the end, the outer tubes being joined by a cross connection. That is, the return bends are not surrounded by the outer tube and the efficiency of the interchanger is consequently reduced.

An advance in design has recently been made by welding the outside return bend around the inner one so that the double pipe is continuous. To do this a short length of pipe is split with the cutting torch and the two pieces heated with the torch and bent around suitable dies to form the two halves of the outer return bend. The two pieces are slipped over the inner bend and then welded together. The result is a coil with maximum heat exchange surface.

Welded return bends on the heating coils for a furnace are used in some types of pipe stills.

Vapor lines from stills to towers or condensers and run-backs from towers give no trouble from leaky joints when welded.

Welding is standard practice in many refineries for the construction of manifolds and headers for condensers, pump house connections and a variety of miscellaneous applications.

An example of repair work in this department is a repair on an oil filter. This was cracked along one side just below the lugs. Welding quickly put it in working order again.

CLAY DRIER

For drying clay that had been used to decolorize gasoline, a Western refinery developed a novel steam coil. The two-inch arms are flattened and welded shut at one end, the other being welded to the central eight-inch header. The coil is set inside a cylindrical tank with the header vertical. Clay is fed in at the top of the tank and withdrawn through the conical bottom completely dry.

Handling of acid sludge is a problem even where acid recovery systems are installed. At one plant Alcumite valves and fittings were used in conjunction with copper pipe to overcome corrosion in the pump headers. It was found impossible to make the screwed joints between pipe and fittings sufficiently tight until someone suggested bronze-welding. A little bronze run around each joint quickly stopped the leaks. The fittings at the right had been in use and developed leaky joints before bronze-welding was done; those at the left were bronze-welded before use and were perfectly tight from the start.

As indicated previously, marked economies may be effected by using salvaged pipe for various supporting structures about the plant. Substantial and attractive stanchions for overhead steam lines and electric cables can be quickly welded from odd pieces of used pipe. The same method can also be used for ladders, hand rails and guards.

From the many enumerations of welding applications set forth in this article it can clearly be seen that there are opportunities aplenty for the use of welding equipment about a refinery. Progressive refiners have long been cognizant of this fact and today more than ever, they are keenly alive to the many advantages accruing from the use of welding in maintenance and plant repair work.

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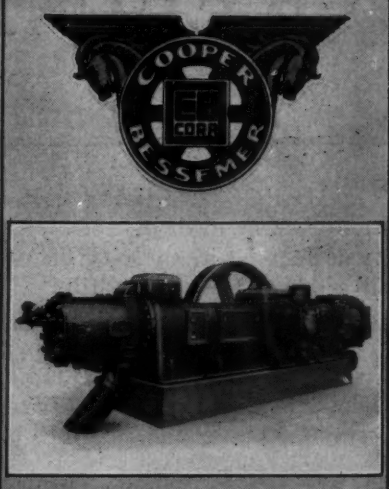
FC-E — Oil well pumping. Driving pumping powers. Driving water pumps or air compressors.

E P — Direct-driving electric generators for auxiliary power in oil pumping stations. General power purposes.

22 — Main line compressor station service. Natural gasoline extraction in very large plants. Electric power station service. General power purposes.

19 — Main line compressor station service. Natural gasoline extraction in large plants. Medium size electric plant service. General power purposes.

ERTICAL — Furnishing power by belt-driving or driving electric generators for: Air lift for flowing oil or water wells. Auxiliary power in gasoline recovery plants and compressor stations. Isolated power plant service. Pumping plant service.



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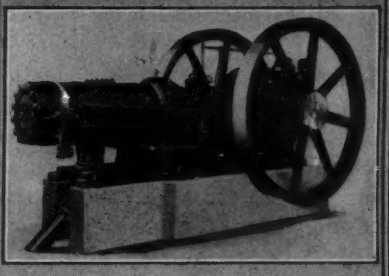

TYPE E.C.
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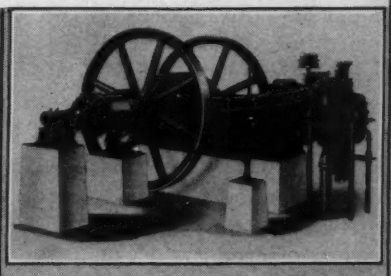

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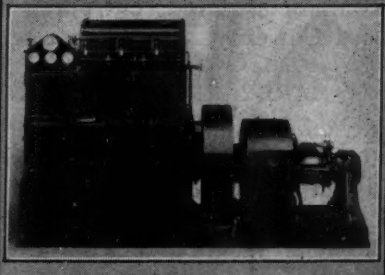

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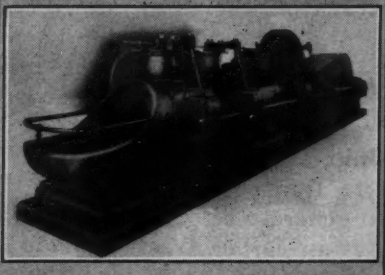

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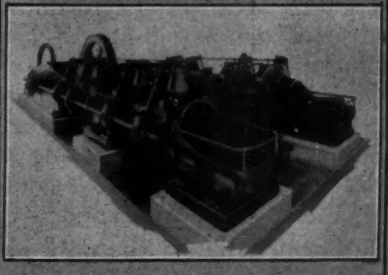

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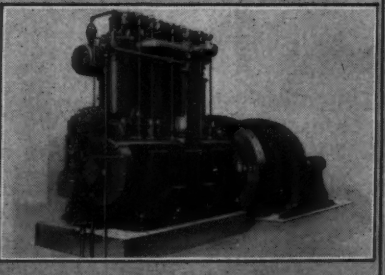


VERTICAL
(75 TO 565 B.H.P.)

REFINING IN MEXICO

By GEORGE BLARDONE

COMMERCIAL refining of petroleum in Mexico commenced in 1886. The first refinery was located in the city of Vera Cruz. It was a small affair of only two stills with a carging capacity of 500 barrels. At the peak of the petroleum industry in Mexico in 1919-1922 there were 14 plants in the republic, skimming plants and full refineries, with a daily capacity of 360,000 barrels of crude. Today not more than four plants are in constant operation.

Some of the plants, erected during the hey-day of crude production, scarcely functioned at all; and now, at least four have been dismantled and abandoned, while others, which are shut down, are simply marking indefinite time, and for all practical present day purposes may just as well have never been built.

In 1886 a company styling itself Mexican Petroleum Company (a name that was adopted 15 years later by the Doheny-Canfield interests when Ebano was acquired) constructed a refinery at Vera Cruz to refine crude petroleum and distribute the product in the domestic market. The products were kerosene, lubricants, greases and paraffin. They were offered under the trade mark "El Aguila" (The Eagle), the distinguishing trade mark at this time of Mexican Eagle Oil Company, of the Royal Dutch Shell group, which came under the latter jurisdiction when the Shell combine acquired controlling interest from the late Lord Cowdray, a few years ago.

EARLY MEXICAN REFINERIES

Crude oil to supply this refinery was imported from the Pennsylvania fields, in the United States, possibly in barrels, as tank steamers to transport liquid cargoes in bulk did not come into general use until later, although they were known at an earlier date.[1]

In 1887, Waters Pierce Oil Company entered Mexico and constructed a refinery in Vera Cruz, which was the key port to the interior by virtue of its rail connections. Mexican Petroleum Company, confronted with the possibility of active competition, sold its plant to the Waters, Pierce people, and retired from business. The latter company commenced refining similar products, introducing them to the Mexican market under the trade mark, "El Gallo" (The Rooster), a brand that is continued by its successors, Pierce Oil Corporation.

Vera Cruz continued the only refinery in Mexico until 1898. In that year, Waters, Pierce completed and commenced operating its refinery at Tampico, a plant with a daily capacity of 10,000 barrels. Selection of Tampico probably was influenced by the fact that Henry Clay Pierce was interested in the Mexican Central Railroad, which was then entering Tampico, a port of entry, from the interior. Certainly the selection of Tampico for the site of the big plant could not have been influenced by propinquity to domestic production, for in 1898 there was no crude production in Mexico. The prolific pools near Tampico were destined to be discovered at a later day. The Pierce people have made only sporadic attempts to provide their own crude production, although the opportunity to do so was theirs many times, as the various pools in the Tampico-Tuxpam embayment were discovered and proven by the drill. Pierce Oil Corporation's refinery at Tampico has always purchased practically all of its crude, importing it from the United States until domestic production reached a point where this was no longer necessary.

Incidentally, the little plant at Vera Cruz was not abandoned, but continues to function, serving territory contiguous to the latter port.

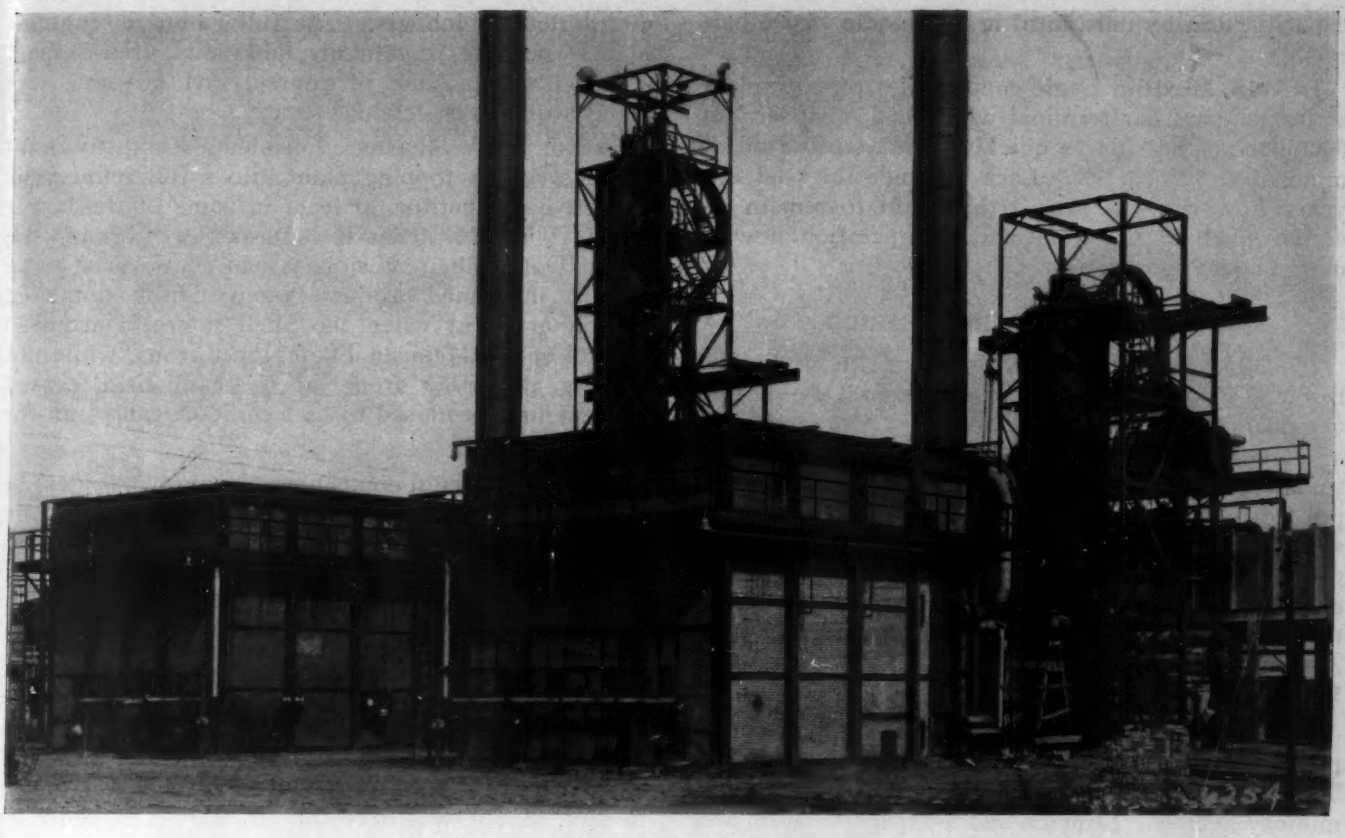
TEHUANTEPEC REFINING

Ten years after completion of the Pierce Oil Corporation's refinery at Tampico, Mexican Eagle Oil Company finished its 15,000 barrel plant at Minatitlan, on the Isthmus of Tehuantepec. Location of this plant on the Isthmus was no doubt influenced by discovery in 1904 of the San Cristobal pool by the same interest and, further, by the facility afforded by the Isthmian short line railroad to reach the Pacific coast with refined products by way of the port of Salina Cruz. Nor were rail facilities direct to the capital of the republic and to interior centers generally lacking. Unfortunately, San Cristobal and other Isthmus pools did not measure up to early promises. The Minatitlan refinery was compelled to import crude from the United States until 1912, when sea loading lines established at the company's terminal at the mouth of the Tuxpam river were perfected. This made available production from the company's big Potrero del Llano well, which had been completed in the last days of 1910. From that day the Minatitlan refinery has operated principally on crude supplied by coastwise tanker bottoms from the Tampico-Tuxpam embayment pools.

For a number of years Isthmus production was practically nothing. It was increased in 1926, however, and the following year it reached its greatest volume in any one year with a production of 2,769,769 barrels.

In 1914, Mexican Eagle Oil Company completed the first unit (12,500 barrels) of its extensive plant in Tampico, and a pipe line was laid to provide it with the necessary crude from the company's pools in the southern fields. This plant has been increased in

[1] "Tankers", by E. M. Clark, The Oil Weekly, May 25, 1928. "Modern Tank Steamships", by John G. Pew, Mining and Metallurgy.



5,000 Barrel Crude Distilling Units

Two distilling plants each having a rated capacity of 5,000 barrels of crude per day, are here shown. The units were designed and completely erected by the Foster Wheeler Corporation.

The Foster tube stills are shown in the foreground with the fractionating towers and heat exchangers placed behind them.

Gasoline, to end point specification is recovered as the overhead vapor stream. A side stream of gas oil is taken off from a stripping section. Fuel oil is removed as bottoms.

Provision is made in the design of the towers for the removal of additional side streams in case lubricating oils are desired.

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capacity, unit by unit, until it can handle 75,000 barrels.

In 1918, Mexican Eagle completed a topping plant at its Tuxpam bar terminal which had a capacity of 5000 barrels, but it was quickly increased to a maximum of 29,000 barrels. Lack of crude the past few years, however, has caused this plant to remain inactive much of the time, and its operation now is more or less sporadic.

STANDARD ENTERS TAMPICO

In 1914, Standard of New Jersey, now known through its subsidiary, Transcontinental Petroleum Company, finished a topping plant at Tampico, with an initial capacity of 6000 barrels, which was destined to be trebled in a short while. This plant suspended operations three years ago, owing to lack of suitable crude. In 1915, Huasteca Petroleum Company (formerly Doheny, now Standard of Indiana), completed a topping plant at its Tampico terminals that was eventually to be evolved into a full refinery. As a skimmer this plant has a capacity of more than 100,000 barrels.

The years 1919 up to and including 1921 saw topping plants and refineries spring up like mushrooms. The Mexican government had created Port Lobos, midway between Tampico and Tuxpam, in 1918, and four topping plants were constructed there. They were: The Texas Company, capacity 10,000 barrels; Cias. Refinadora del Agwi (Atlantic Gulf Oil Corporation, 9,000; Atlantic Refining Company, 9,000; Island Oil & Transport Corporation, 5,000.

At Tampico, the following additional plants were constructed: The Texas Company, 10,000 barrels; Continental Mexican Petroleum Company (General Petroleum Company of California), a refinery planned on unit system for three units of 10,000 barrels each, one unit fiinshed and operated for short while as a skimmer; Cia. Mexicana-Holandesa La Corona, S. A., (Royal Dutch Shell), a refinery, 30,000.

Of this galaxy of refineries and skimming plants, new and old, the only ones that can be said to be in constant operation (not necessarily operating at maximum capacities) are Mexican Eagle's Tampico and Minatitlan refineries; Pierce Oil Corporation's Tampico refinery and Huasteca Petroleum Company's plant. As has been indicated, the Port Lobos plants are abandoned; The Texas Company's Tampico refinery skims a little crude now and then, and this sporadic operation also applies to Mexican Eagle Oil Company's topping plant at Tuxpam bar. The remaining plants, susceptible of operation, are shut down—indefinitely.

FACTORS OF DOMESTIC MARKET

Mexico probably is best served with petroleum products by the two oldest companies owning refineries, Pierce Oil Corporation and Mexican Eagle Oil Company. These companies have a network of sales stations in the principal cities and towns of the republic, and where they are not directly represented by their own agencies, their respective products are distributed by jobbers. The full gamut is contemplated: gasoline, illuminants, lubricants, greases, paraffin, et cetera, and, of course, fuel oil—this last being a quite respectable item.

In late years, Huasteca Petroleum Company, having evolved its topping plant into a full refinery, is an active competitor, at least in some of the larger cities. Cia. Mexicana-Holandesa La Corona, the Royal Dutch Shell subsidiary, had commenced some activity in refined products when it first completed its refinery; but when the Shell interests acquired control of the Mexican Eagle, the Corona, while not retiring altogether from the domestic field, ceased what at first promised to be a militant campaign for its share.

Some few foreign companies do a small business in Mexico with their respective products, but, with the possible exception of The Texas Company, this invasion is more academic than actual.

ASPHALT MANUFACTURING

When the Doheny interests proved the Ebano field there was no particular market for the low gravity (say 12 degrees B.,) production of this field. It was quite a task getting the railroads in Mexico interested in this black, viscous liquid fuel—a fuel so viscous, in fact, that it was necessary to heat it in order to handle and utilize it. And two decades or more ago the world was not educated to the use of fuel oil as it is today—especially a low gravity fuel oil. It required a patient and painstaking educational campaign to get fuel consumers to realize the economic value of heavy Mexican crude as fuel. It was natural, therefore, that at this time one of the quickest methods of commercial utilization for this grade of oil that readily suggested itself was the manufacture of asphalt. The Mexican Petroleum Company constructed an asphalt factory at Ebano, and this plant manufactured asphalt in considerable volume for a number of years, exporting the product freely, and finding no small market for it in the republic itself, especially in the days of Porfirio Diaz. The flood of Trinidad asphalt depressed the market around 1910. This depression abroad synchronized with the fall of President Diaz, and the commencement of the financial depression in the republic, a depression that was the outcome of the disturbed political conditions that folowed the fall of Diaz.

By 1912, the asphalt plant practically shut down, nor has it ever resumed the manufacture of asphalt for the general market, either at home or abroad.

In 1917, Pierce Oil Corporation constructed an asphalt unit in its Tampico refinery. It manufactured this material for a brief time, exporting to the United States in that year, 24,667 barrels. If the unit has been operated since then it was for small, domestic orders only.

In 1926, Mexican Eagle Oil Company dispatched 106,910 barrels from its Tampico refinery, practically all of which was exported. In the year following Mexican Eagle's Tampico plant dispatched 1,730,149 barrels, most of which was exported. The range of this last year's exportations was considerable, con-

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templating the United States, Cuba, the Continent, United Kingdom, South Africa, Malasian ports and Australia. Statistics covering the volume of asphalt, if any, manufactured at the Minatitlan refinery are not available.

CASINGHEAD GASOLINE

But little attention has been paid to casinghead gasoline by producers in Mexico. In the first place, gasses in the northern fields district are valueless, containing a high percentage of carbon dioxide. In the south fields district, the gases are rich in gasoline forming hydrocarbons, and casinghead gasoline is being extracted in that district to a certain extent.

The first company to extract casinghead gasoline was Penn Mex Fuel Company, which, about 1916, erected a small plant for this purpose at its Alamo field. This plant was of the compression type, originally planned for three units with a maximum capacity of 500 gallons per day from each unit. The company's idea at the time was to extract gasoline for its own use. The product extracted was quite volatile, having a gravity of 72. Recent reports, emanating from the Department of Petroleum in Mexico City, credits the company with planning a much larger plant for its Paso Real field, it being stated that the new plant will be of the absorption type.

Later on, Huasteca Petroleum Company erected an experimental plant at its Juan Casiano field to extract gasoline from the gases derived there. This plant was of the absorption type, and it has been estimated that a gross yield of seven quarts per 1000 cubic feet was extracted. Transportation of this product, owing to its extreme volatility, without laying a special pipe line for the purpose, was a problem that was solved for the time being by pumping it into crude oil, and so transporting it through the crude pipe line system to the company's topping plant at Tampico, where it was extracted from the crude by the simple process of topping it out along with the gasoline content of the crude. Huasteca has long had a much larger plant of the same type at Cerro Azul. This company had always utilized part of this gas for fuel at its Casiano field, during the long life of that pool, at its several pump stations along its trunk pipe line and at its terminals at Tampico.

In tabulating the distribution of crude production in Mexico in 1927 a total of 15,197,008 barrels was credited to domestic consumption.

Compact Gasoline Plant Gives Low Labor Cost

IN compactness, efficiency and neatness of appearance, State Gasoline Company's No. 4 Plant at Signal Hill ranks as one of the outstanding natural gasoline installations in California. Built in record time and located on a plot only 150 by 150 feet, the plant was placed in operation to handle gas from Signal Hill wells at a critical time. Both the compressor and boiler plants are located on the small plot, yet there is a surplus of room. This compactness of design has reduced labor to a very small fraction of the total operating cost.

The gas comes from the wells at a slight vacuum to the Mist-D-Fier for the purpose of recovering all entrained mud and heavy oil. The old practice was to run the gas directly to the plant without this necessary cleaning operation.

The compressor plant consists of four 165-horsepower Ingersoll-Rand duplex compressors which receive the gas at a slight vacuum and discharge it at 35 pounds pressure. This plant is at the front of the lot, occupying only a narrow strip and opening toward the main plant to give the operator a view of almost every installation from any angle.

The cooling tower embodies the latest accepted practices in natural gasoline plant construction. The coils are Campbell open Louvre type and consist of two-inch and three-inch pipe coils in 12-inch headers. All pipes are clean and shiny, due to the pressure with which the water is sprayed from above. The cooling tower occupies a strip along the side of the plot.

From the cooling coils the gas is taken to an accumulator scrubber of the Mist-D-Fier type. Due to the fact that gas comes to the plant at a slight vacuum, some of the heavier fractions pass through to the accumulator scrubber. The condensate cooled out in the gas cooling coils so thoroughly wets the baffles in the accumulator scrubber that a large amount of film surface is formed, which in turn removes all trace of contaminating fractions and water. The absorber oil is practically as clean as when the plant started. The efficiency of the separators is brought out by the fact that the gauge glass on the inlet scrubber shows the throwout to be a black crude, while the throwout in the accumulator is a dirty straw color.

Two large absorbers handle the gas in an efficient manner. Each has a capacity of 12 million cubic feet daily and will handle 400 gallons of absorption oil per minute at 30 pounds pressure. They are a typical Campbell installation and are 7 feet by 28 feet and of 16-plate construction.

From the absorbers, the dry gas passes to the street outlets after boiler and plant requirements are met.

The cold oil enters the absorbers at an average temperature of 70° and leaves the absorbers by automatic float controls. It is then picked up by the fat oil pumps, which are also operated by floats in the base of the absorbers, discharged through the heat exchangers, the preheaters and into the evaporators at a final temperature of 346°.

The lean oil leaving the evaporators is forced by the

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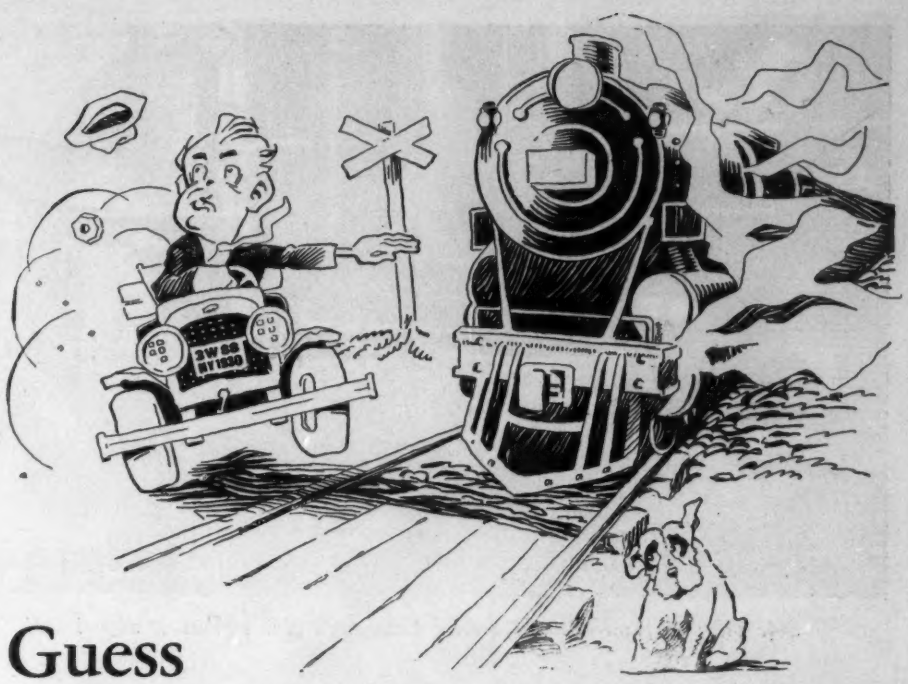

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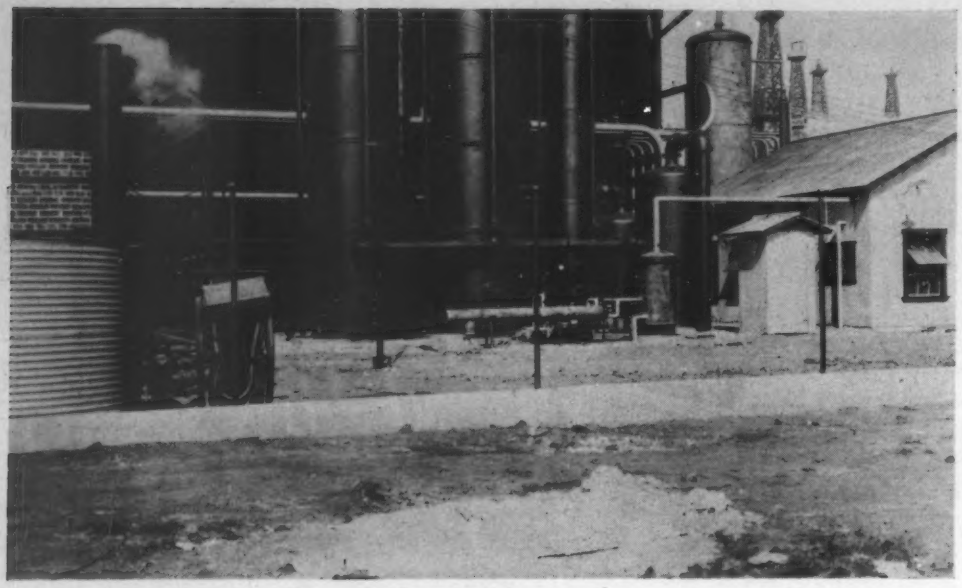


Side view of plant—State Gasoline Company's No. 4 plant at Signal Hill

evaporator pressure through the outer shells of the heat exchangers, emerging at a temperature of 112°, and is picked up by the lean oil pumps, discharged through the cooling coils and, entering the top of the absorbers, starts another cycle.

Vapors leaving the top of the evaporator pass into a conventional Campbell dephlegmator on top of the cooling tower and after partial condensation pass into a mist extractor, where the reflux drops down to a de-watering tank and gasoline vapors pass to the condensors.

The de-watering tank, by means of a balanced float, discharges the condensed agitation steam and the reflux proper flows by static head through the reflux heater into the reflux rewash section located on top of the evaporator.

This system of hot reflux, by keeping the still at maximum temperature, enables the evaporator to completely strip the oil of gasoline fractions, which in turn greatly increases its efficiency as an absorbing medium.

The reflux, in passing through the heater, is brought up to the same temperature as the oil entering the evaporator.

The finished gasoline is de-watered in an automatic tank and stabilized in a low pressure stabilizer, the vapors from which are fractionated by condensate from overhead and are selectively reabsorbed in the reabsorber, which also handles the uncondensed vapors.

The high latent heat developed in the reabsorber is very successfully disposed of by taking the oil from the base by a small steam-driven pump, discharged through small cooling coils and re-introduced at the sixth plate. This system of stabilization produces 91 recovery gasoline with present setting of controls, and the discard from the reabsorber by analysis shows practically no fractions of value.

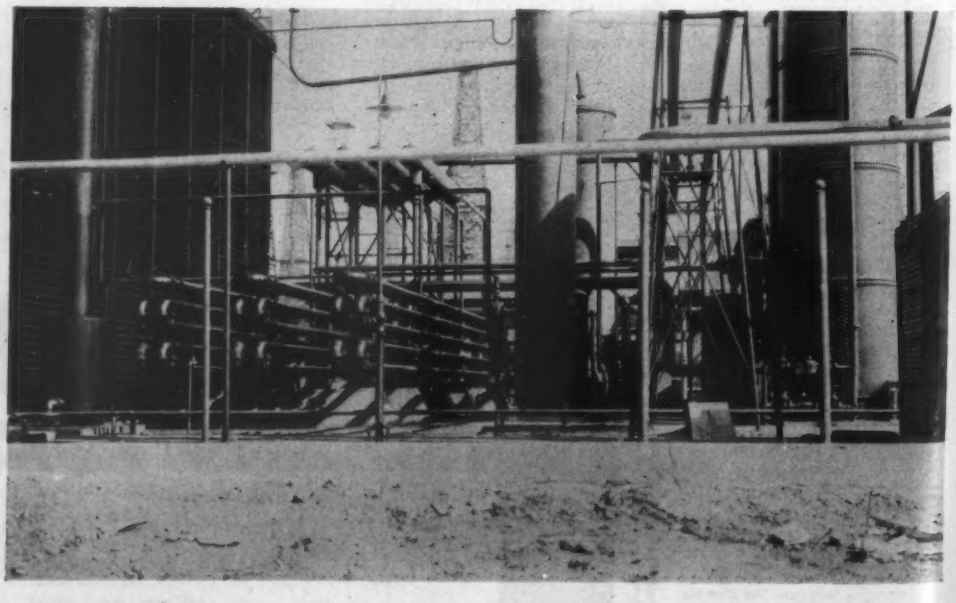
The condensate thrown out in the accumulator scrubber is handled in a very small preheater and evaporator, the vapors being introduced in the main vapor system.

One of the outstanding features of the plant is the battery of interchangers, which handle the full oil circulation, heating it from 85° to 290°. The oil is cooled from 325° to 112°.

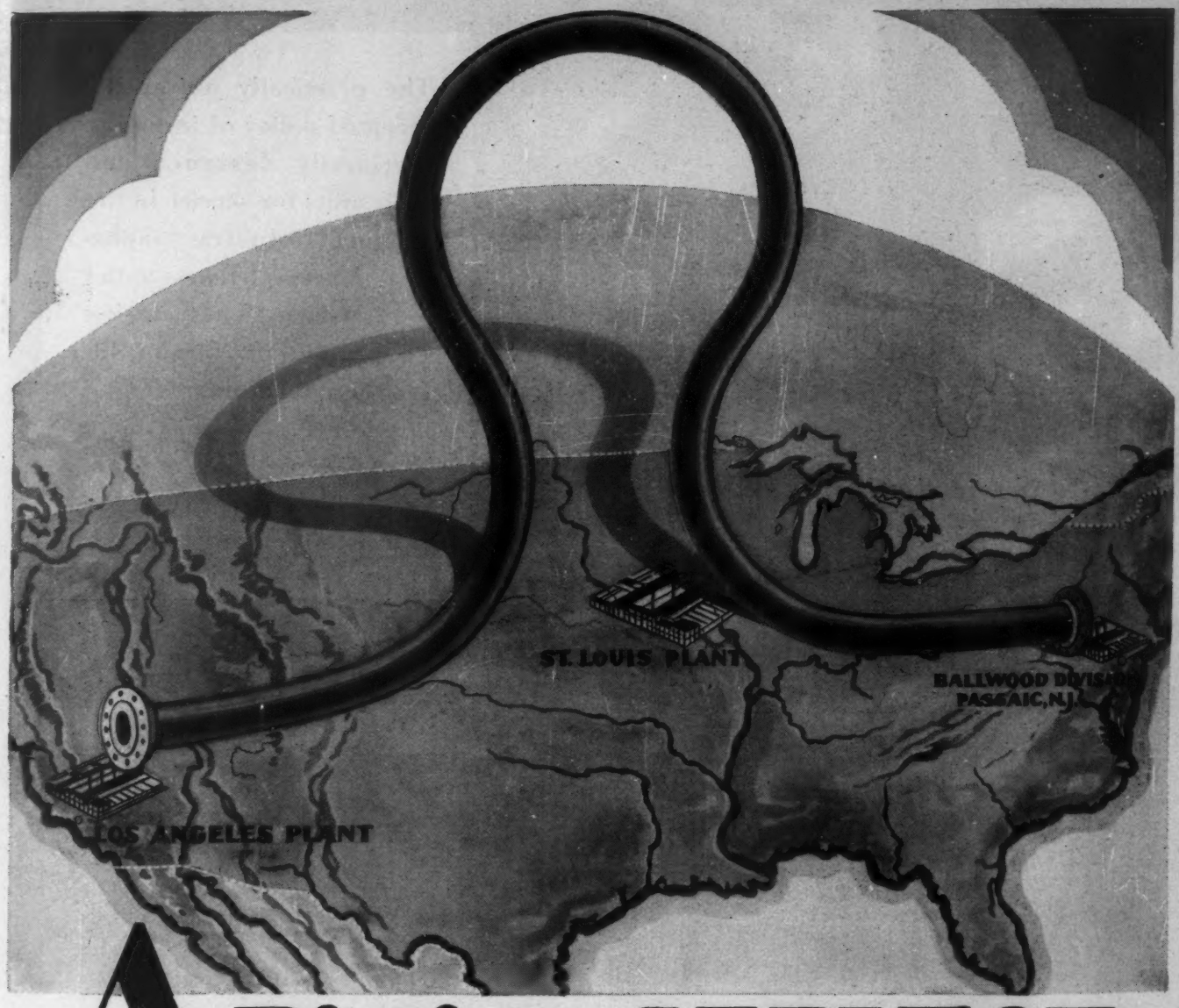
One of the improvements noticed in the plant is the integral type of float control used. The shaft and packing gland are mounted on a 10-inch flange so that the entire float assembly can be removed for inspection or replacement. The floats are of large diameter with long shafts and give a powerful leverage for operation of balanced valves.

The boiler plant consists of four 175-horsepower Titusville boilers, with two steam headers, one supplying the pumps and another the elevated preheaters, from which condensate returns to the boilers by gravity. The load is light, due to the decided reduction of steam required by preheaters, which in turn is caused by the high temperatures of oil entering the preheaters from the heat exchangers.

The plant is obtaining an extraction of 2.4 gallons per thousand cubic feet of gas, which is considered an unusual average.



State Gasoline Company's No. 4 plant at Signal Hill, showing compactness of design



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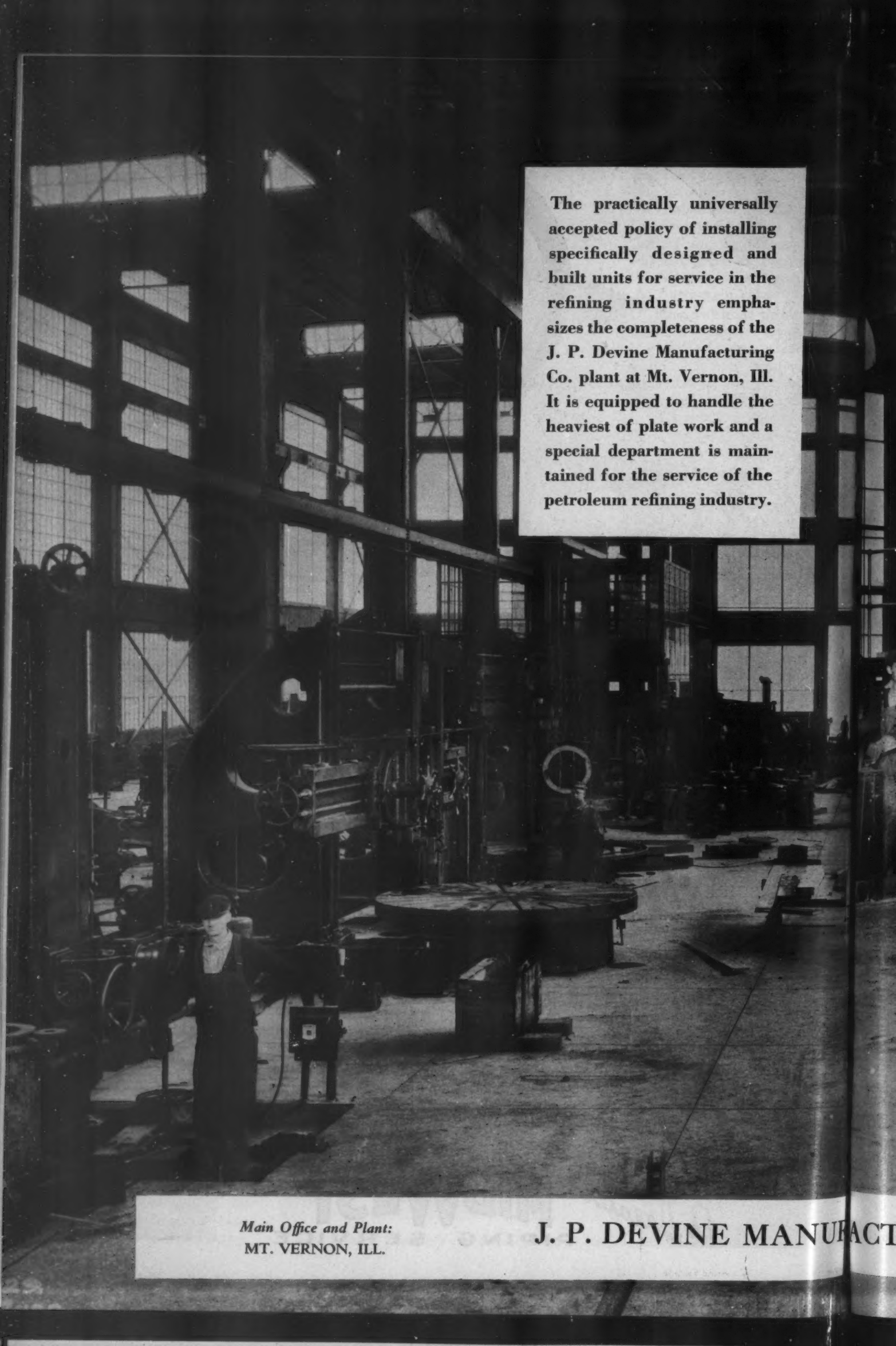

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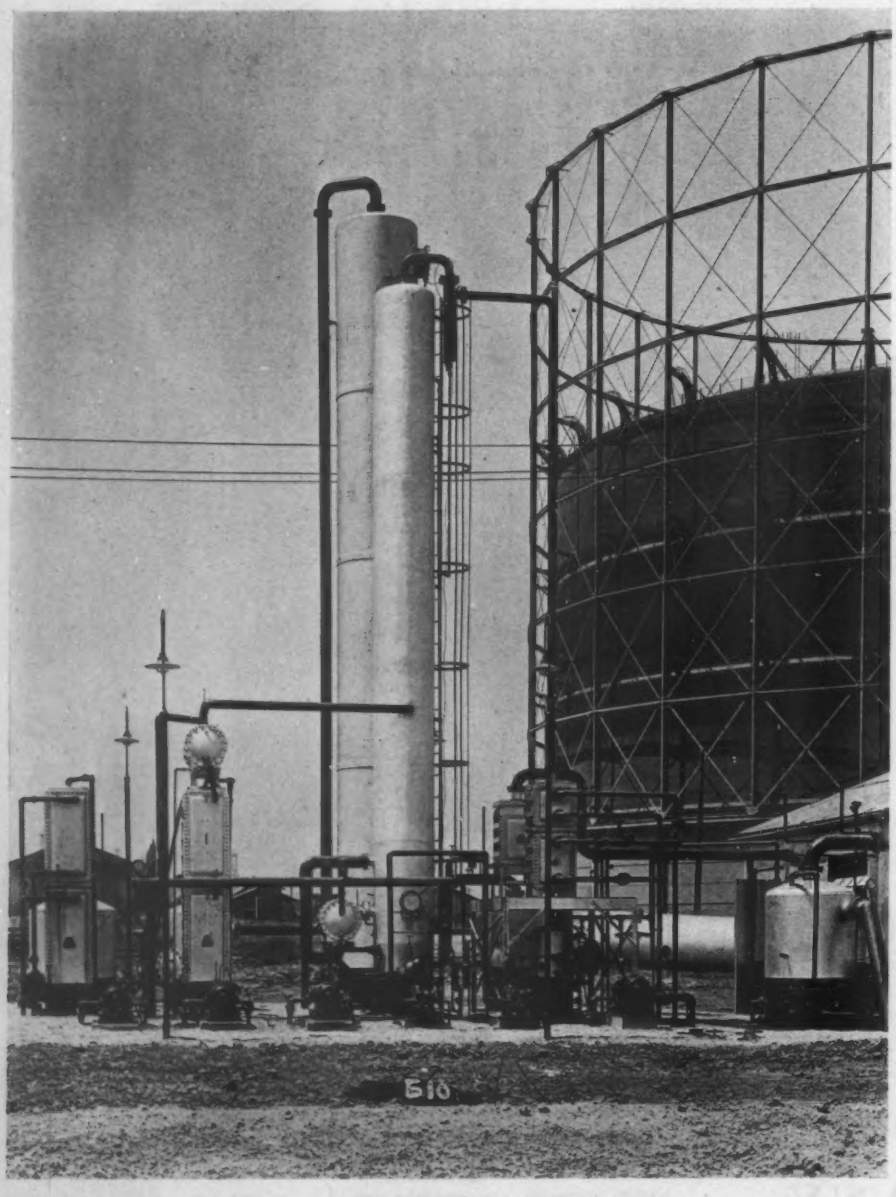
Novel Features at Hancock Plant at Long Beach

By BRAD MILLS

HANCOCK Oil Company, through the incorporation of many novel and efficient installations, has not only managed to keep its Signal Hill refinery up-to-date, but has also been able to operate successfully under the most adverse conditions within the petroleum industry. Completed late in 1923 and placed in operation January 2, 1924, many additions have been made to the original plant, while daily crude runs have been increased from 1000 barrels to more than 12,000 barrels. This growth has been gradual, but each year the increase has been accomplished by expansion within the company itself.

Ideally located on Signal Hill and only a stone's throw from a potential production of 175,000 barrels, the refinery is operating almost exclusively on Long Beach crude. Some Santa Fe Springs crude has been refined during the overproduction in that field and connections to other Los Angeles basin fields may be made in a short time. The source of supply is one of the steadiest in the Los Angeles basin, with the company's own Long Beach production caring for the plant's major requirements. A 27½-acre tract provides ample room for storage tanks and auxiliary installations.

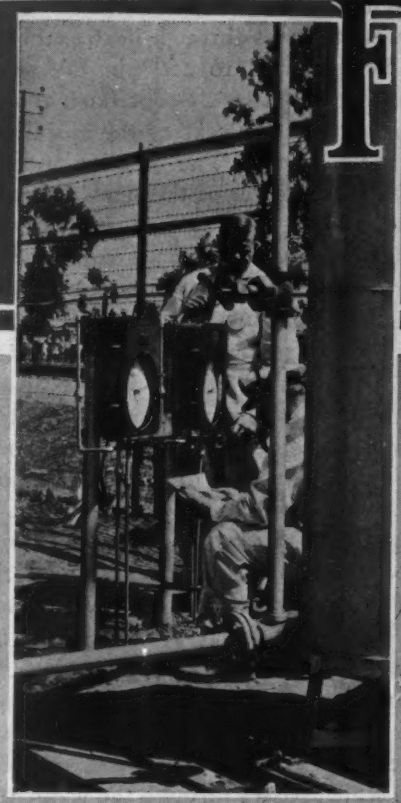


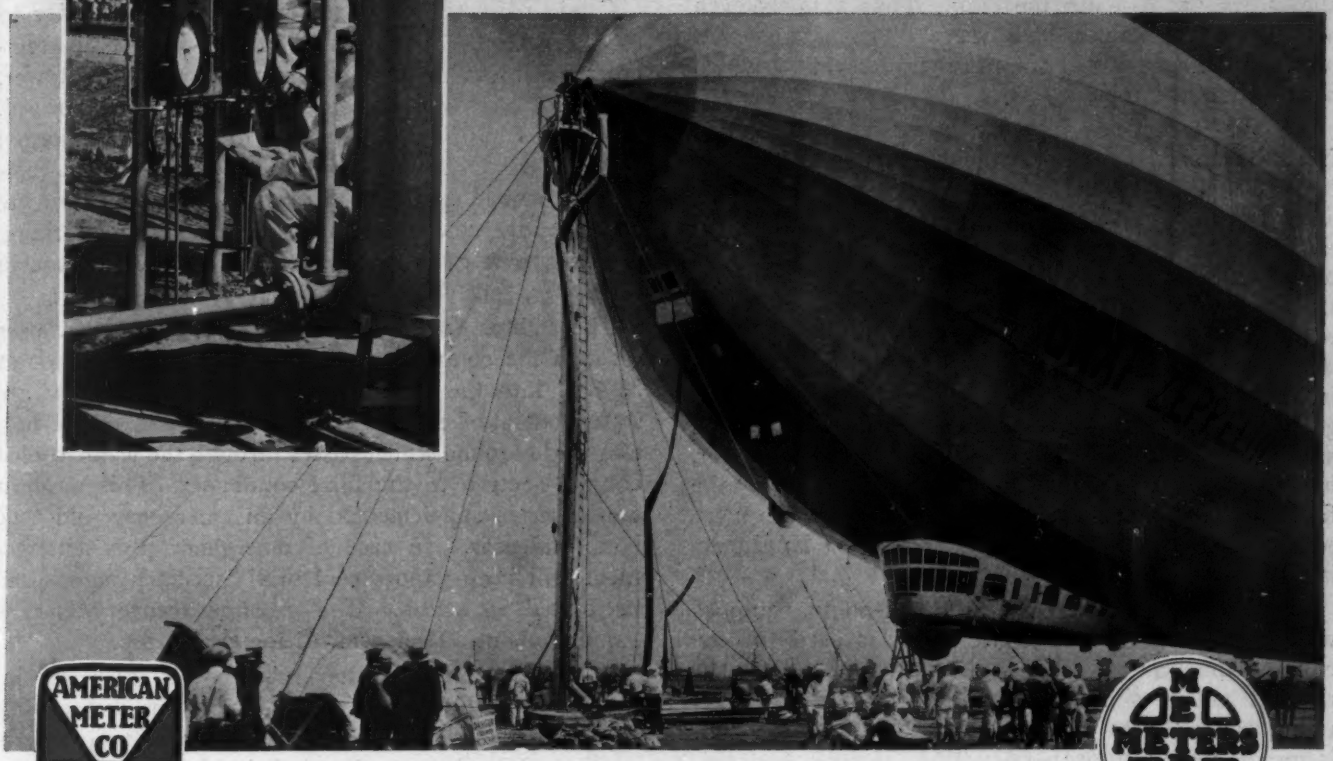
Vapor recovery plant, Hancock Oil Company, Long Beach, California

From the field gathering lines, the crude comes to the master meter through one six-inch and two four-inch lines. This Bassler, thermostatically controlled meter is the largest in the world and has attracted much attention. It will measure crude at the rate of 120,000 barrels per day and would easily handle all of the oil produced in the Long Beach field, under the present curtailment program. The measuring device corrects the crude to 60°F. and records the proper total with each stroke. The meter is equipped with an automatic sampler which forces out a small quantity of crude each time the lever "kicks," the result being a net average cut on a day's run. This method is in sharp contrast to the old haphazard way, of making occasional cuts from the incoming line. Tests of the samples may be taken several times daily and averaged, but the results have always checked closely with a test of the entire day's run. The sampler works on a piston on the incoming line.

The hookup is such that it is possible to run into a tank from the field and pump from the same tank to the stills at the same time. The daily runs are obtained by a check of the meter. A check may be maintained against the meter but this has not been necessary, the field measurements having been sufficient for all

FUEL FOR THE GLOBE-CIRCLING GRAF-ZEPPELIN *must be proportioned and measured with great accuracy*





AMERICAN METER CO
MEASUREMENT ENGINEERS
CUBIC FEET

Large photo above shows Graf Zeppelin taking on gas fuel at Los Angeles during round-the-world flight . . . Inset shows Westcott Orifice Meters used to insure accurate mixture of 36% natural gas and 64% Pyrofax.

ON her recent spectacular flight around the world, the Graf Zeppelin used gas fuel in her engines. Approximately 175,000 cubic feet of gas were taken aboard at Los Angeles, where refueling required about 12 hours. Throughout this period it was necessary to mix absolutely accurate proportions of natural gas and Pyrofax. Two 50-inch Westcott Orifice Meters were used to secure the exact control required.

Two Westcott Orifice Meters were used in a similar set-up for refueling at Tokio. This, the dramatic world-flight, furnishes further evidence of the part played by the products of American Meter Company in the industrial and technical achievements of the day.

WHEREVER ACCURACY IS ESSENTIAL, USE

METRIC orifice METERS

METRIC METAL WORKS
ERIE, PENNSYLVANIA
IRONCASE, TINNED STEEL CASE and ORIFICE METERS

AMERICAN METER COMPANY
INCORPORATED
The World's Largest Manufacturers of Gas Meters and Allied Apparatus
ESTABLISHED 1836

Sales Service: Erie Dallas Tulsa Denver Los Angeles San Francisco Kansas City Pittsburgh Chicago Philadelphia New York Baltimore Boston Albany

practical purposes. A constant check is naturally made through the medium of gaugers' tickets, which include both the company's oil and that purchased.

VAPOR RECOVERY SYSTEM

All gasoline and crude tanks are equipped with vapor recovery installations, the outlet lines leading to one of the most complete vapor recovery plants in this district. The tank arrangement includes one pressure regulator and one vacuum regulator. When the tank pressure reaches two inches of water, the regulator opens to the vacuum line. When a similar pressure is reached in the vacuum line, the vacuum regulator opens and allows dry gas to enter the tank. Thus a fairly even pressure is maintained both ways. The arrangement prevents the entrance of air into the tanks, all of which have water-seal tops.

All gas is metered into the vapor-recovery system from the tanks. A vacuum regulator holds a pressure of about 10 inches of water on the main gathering line from the gasoline and crude tanks. Two 12 x 19, electrically driven Worthington-Laidlaw compressors pick up the gas and boost it to a pressure of 30 pounds. It is then cooled and sent to small absorbers. The enriched oil enters the still at 315° F., under a pressure of about 40 pounds. About a half-million cubic feet is being treated, the recovery averaging about 2000 gallons per day. Some of the gas treated yields as high as eight gallons of gasoline per thousand cubic feet, but the average is much less. The gravity of the finished product is about 95 A.P.I. The vapor recovery plant was built throughout by Southwest Engineering Corporation.

A 1½-inch Worthington centrifugal pump, equipped with a five-horsepower electric motor is used for circulating the lean oil, with the same type handling the rich oil and a similar installation "standing by" for emergency. These small pumps have proven amply large for their purpose.

To overcome the difficulty in handling the 95 gravity gasoline, a 4½ x 6 Worthington, single action, marine type steam pump has been installed. The ordinary type of pump handled this troublesome liquid only with difficulty.

The vapor recovery plant is automatically controlled by a Foxboro combination recorder and controller. This attachment on the still is designed to operate with a still pressure of 40 pounds and a rundown tank pressure of about 15 pounds. The finished product is pumped to the rundown tank, but when the temperature rises in the still, the recorder closes the valve to the rundown tank, forcing cold gasoline to the top of the still. This maintains a still temperature of about 190°F.

Water for the cooling system is obtained from the cooling plant of the main refinery. It is used and sent back to the main system with very little loss.

The refinery is composed of two units, one with a capacity of 3500 barrels and another with a normal rating of 8500 barrels. Both were built by Southwestern Engineering Corporation. The method of running crude through both units is practically the same, with straight run principles being used exclusively.

REFINERY OPERATION

Cold crude entering the system is pumped through the control section on top of the first fractionating tower, where its temperature is raised from 80° to 100° F. From this tower it passes through heat exchangers, the temperature being raised to 250° in the process. Upon entering a seven-foot by 24-foot flash tower at this temperature, about 25 per cent of the gasoline and all of the water is vaporized. The gasoline and water vapors pass into a second tower of the same dimensions, where most of the water is condensed and drawn off and any heavy distillate carried over is condensed and run back into the crude. The gasoline coming from this tower is a finished product, requiring no treating.

Crude from the flash tower is pumped directly to the retorts, where it is heated to 500° F. At this temperature it enters the first main fractionating tower, where all gas oil and lighter fractions are vaporized. The remaining liquid fuel oil is drawn off the bottom of the tower, passed through the exchangers and coolers and sent to storage. Vapors rising in the tower are cooled by the cold crude in the control section, forming a reflux, part of which is stripped by special pans in the tower, thus forming gas oil.

The lighter vapors (gasoline and kerosene) pass through the control section of the first fractionator at 330° F. into the second fractionator. Here they are separated into kerosene which accumulates in the bottom, and gasoline which passes through the water-cooled control section to the final condenser. This modern condenser is supplemented by an emergency, old type box condenser. In case of emergency, this arrangement will keep vapors cool until auxiliary pumps can be placed in action. The gasoline recovery is now running about 30 per cent. of the crude run.

A 250-horsepower water tube boiler is being installed, in addition to a 200-horsepower water tube type and a 250-horsepower Scotch marine type now in use. A six-inch steam line is being laid to all parts of the plant.

Two gasoline loading tanks have been elevated so that trucks may be loaded by gravity. These tanks are filled at night as a safety measure. Two steel racks are also used for loading gasoline from distant tanks. These racks are equipped with remote controls, enabling the loader to fill trucks by pressing a button.

A new laboratory has been completed which is equipped to make any kind of refinery test.

Of the three, 80,000-barrel storage tanks, one is used for gasoline and two for crude oil. One 55,000-barrel tank is used for fuel oil and one for crude oil. Two of the five 10,000-barrel tanks are being used for fuel oil, one for kerosene and distillate, one for gas oil and one for gasoline. Many smaller tanks are used exclusively for gasoline.

Refinery products are sent directly to the company's new ocean loading terminal on the Los Angeles harbor. The arrangement is such that either gravity or pumps may be employed, depending upon the loading terminal's requirements.

Although not one of the largest refineries in California, Hancock Oil Company's plant is one of the most modern and efficient operating in the state.

IF YOUR EVAPORATION LOSSES were waste steam instead of oil vapor —

IF the valuable vapors lost by evaporation through air-leaky tank roofs and gastight roof vents were waste steam, it would make a cloud big enough to demand instant action. Why ignore a big loss just because it takes place invisibly?

A refinery rundown "gas-tight" tank, for instance, handling 1,000 bbls. of 65 API gasoline daily, loses over 1,500 bbls. a year. Equipped with a Wiggins Floating Roof the loss can be cut to about 44 bbls. a year—a saving more than enough to pay for the roof in the first year of its service. Similarly the Wiggins Breather Roof stops losses from standing storage tanks, and the Hortonsphere is used to store "wild" gasoline under pressure to prevent evaporation.

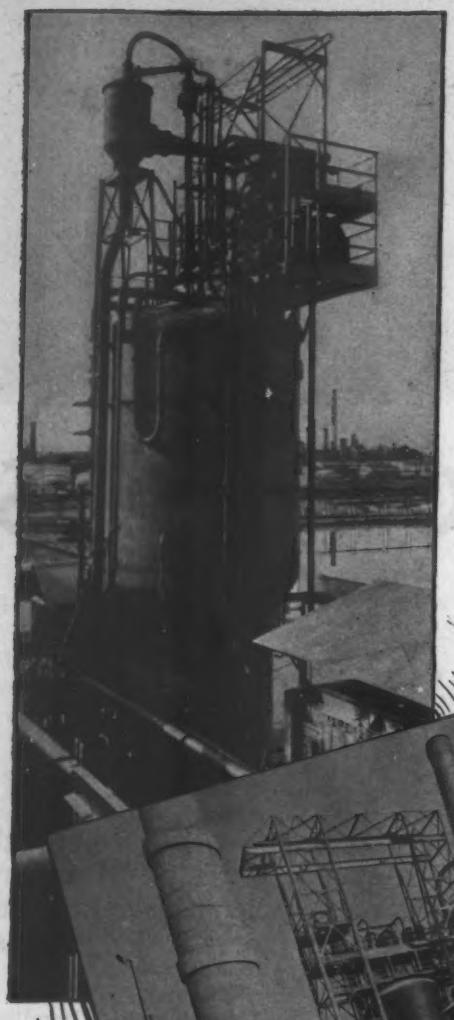
We will appreciate the opportunity of quoting you on re-roofing your present tanks with Wiggins Roofs or quote you on new tanks completely equipped. Our standard capacities range from 500 bbls. up.

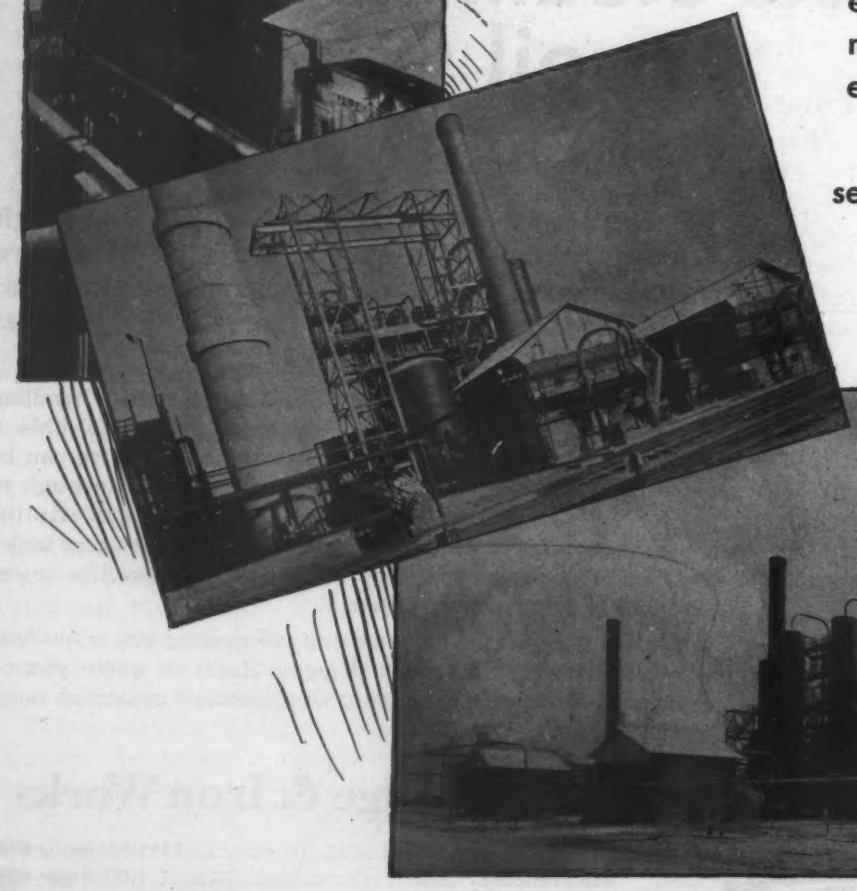
Chicago Bridge & Iron Works

Dallas	3355 Magnolia Bldg.
San Francisco	1051 Rialto Bldg.
New York	3102 Hudson Terminal
Cleveland	2234 Union Trust Bldg.
Chicago	2463 Old Colony Bldg.
Detroit	1520 Lafayette Bldg.
Philadelphia	1608 Jefferson Bldg.
Boston	1529 Consolidated Gas Bldg.

WIGGINS ROOFS
Stop EVAPORATION LOSSES

THIRTY ARGUMENTS





THE thirty names in the panel ment are not all of those for worked by any means; but they ciently representative selec Badger equipment and Badger pressed the oil industry with

Starting with thorough scien competent chemists and en equipped laboratories we es which our designs are based. staffs of skilled draftsmen, engineering specialists. manufacturing and erecting equalled in the oil refining

From clear site to operating service is efficient, reliable and

E. B. BADGER &

NEW YORK TULSA

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of this advertise-
whom we have
constitute a suffi-
tion to prove that
service have im-
their worth.

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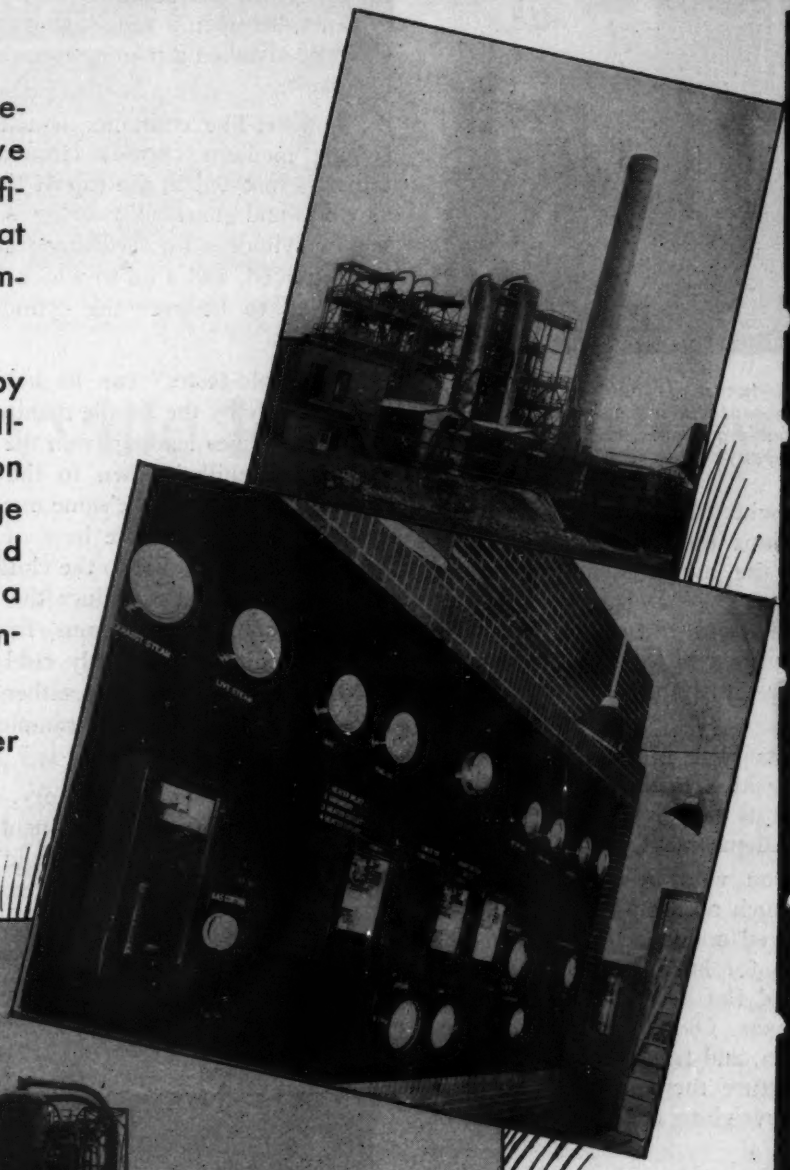
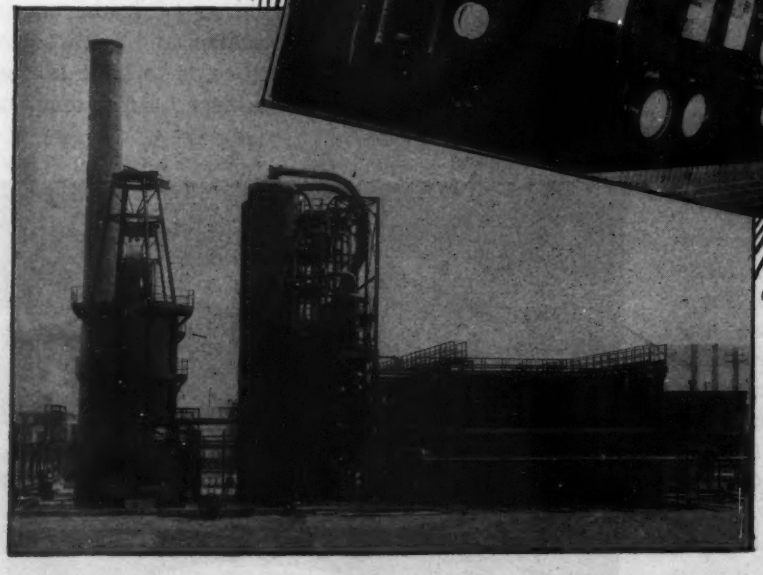
refinery Badger
economical.





The following Companies are some of those who have purchased BADGER Equipment:

Magnolia Petroleum Co., of Texas
Shell Petroleum Corp.
Craig Oil Co.
Freedom Oil Works Co.
Texas Pacific Coal & Oil Co.
Gulf Refining Co.
Skelly Oil Co.
Phillips Petroleum Co.
Pierce Petroleum Corp.
Tide Water Oil Co.
Anglo-Persian Oil Co., Ltd.
Empire Refineries, Inc.
Marland Oil Co.
Vacuum Oil Co.
Associated Oil Co.
Barnsdall Corp.
Humble Oil & Refining Co.
Tidal Refining Co.
Standard Oil Co. of N. J.
General Petroleum Corp.
Beacon Oil Company
Lubrite Refining Co.
Pennzoil Company
Shell Company California
New Orleans Refining Co.
Emlenton Refining Co.
Independent Refining Co.
Richfield Oil Co.
The Texas Co.
Sinclair Refining Co.

SONS COMPANY

LOS ANGELES BOSTON

DEALING IN PERSONALITIES

By GEORGE REID

Few refineries offer the opportunity of photographing a few tons of soap. A large soap manufacturing plant is housed in the new grease and compounding plant recently placed in operation at Pure Oil Company's Marcus Hook refinery

When an oil company with thousands of employes, hundreds of service stations and drilling operations throughout the whole of the country, engages in the manufacture of its own soaps—hand, auto washing, laundry, as well as liquid soaps for shampooing and service station use—it may be a little hard on the soap manufacturers, but it is a profitable venture for the oil company.

Pure Oil Company at its large Marcus Hook refinery, in addition to making all the usual grades of petroleum products, operates its own paint factory and its own soap manufacturing department.

Regardless of where you visit Pure Oil Company properties, and in any branch of the industry, you will find the same green colored and excellent soap. The writer has borrowed soap for hand washing occasions in Seminole, and in a sand flat in West Texas, not to mention refineries in Texas, Oklahoma, Ohio, Pennsylvania and West Virginia, and finally traced this soap to its source. In the picture there is about 20 large cakes of fresh made soap weighing around 1000 pounds each.

Soaps are made by boiling fats and alkalis in large kettles which produce a thick, frothy mixture of soap, glycerin and alkali. Salt is added, which causes the soap to separate and rise to the top and the liquid beneath is drawn off. The usual alkalis are sodium hydroxide (caustic soda) or potassium hydroxide. The fats are tallow, lard, palm oil, cocoanut oil, cottonseed oil, rosin, and olive oil—depending on the type of soap required.

At the right of the picture Resident Chemist G. T. Yost, is standing beside a hand truck loaded with soap ready for shipment—packed in one-pound sizes in wooden boxes. The soaps are sold through Pure Oil Company distributing stations throughout its marketing territory. Laundries, car washing stations, and the like, consume large quantities of the product. Company properties get their share "direct from the factory" at the Marcus Hook refinery.

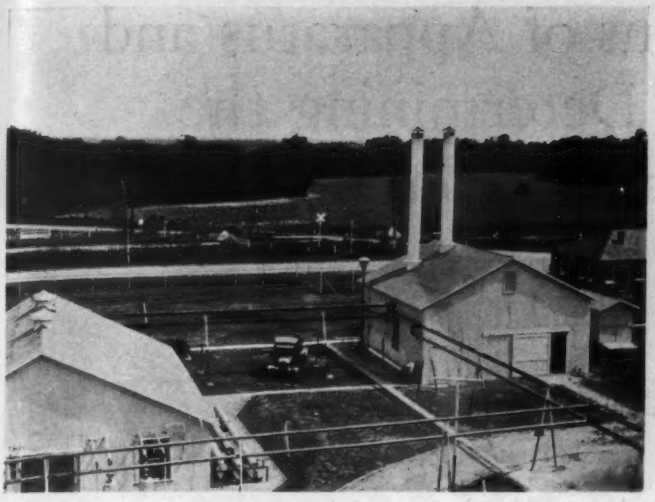
W. R. Reck, superintendent of refinery operations for Bradford Oil Refining Company, Bradford, Pennsylvania, hit upon a time saving and trouble saving idea when he installed a pour-testing device in the refrigerating plant.

A bucket-like container is used through which the cooling medium (brine) circulated. A smaller container is inserted in the top of the bucket with suitable supports and guarded by a ring of cork insulation. Four hollow cylinders for receiving standard pour test bottles are provided, and a lid in which four holes are bored is employed to fit over the cylinders, as shown in the picture.

This "cold-tester" can be held at zero temperature continuously by the simple manipulation of small valves on by-pass lines leading from the centrifugal pump. Or it may be chilled down to the required temperature whenever needed in the same manner. The cold test apparatus stands near the base of the centrifugal pump which circulates brine to the chilling system. This brine is sufficiently cold to reduce the temperature of an oil-naphtha solution to minus five degrees Fahrenheit. Therefore it is sufficiently cold to employ in making cold tests hourly or daily, either on laboratory samples of finished product, or on samples from the stills, etc.

Such a device eliminates the necessity of making up cold solutions in the laboratory. In addition it tends to economy in the same department. Superintendent Reck has taken advantage of his cold brine solution circulation at the point where it is easiest to approach, since the small lines leading to the "cold-tester" lead from the discharge side through the container and back to the pump, and in such small quantities as to have no material effect on the bulk of the brine, so far as temperature is concerned.

Home-made pour test apparatus takes zero temperature brine from the circuit at the pump for chilling samples



Office, power house, and recompressor plant, and well kept yards of Devonian Oil Company plant at Kellyville, Oklahoma

All buildings are kept brightly painted in white, structural steel work and absorbers kept freshly covered in aluminum and the yard kept spotlessly clean

Kellyville Plant Is Beauty Spot

By JOHN ALBRIGHT

OVER in Oklahoma, near Kellyville, where a man by the name of Kelly started a general store way back in the times when Oklahoma was not, but was just a territory where the noble red man roamed and a few ignoble white men preyed upon both the Indians and the more or less legitimate whites. A place where various outlaws and their cohorts were wont to find rendezvous, is a beautiful setting for a natural gasoline plant. Then in the course of time, Tulsa became a metropolis, and demanded more and more fuel for their varied industries, and more and more houses were built which caused a further demand for domestic fuel. The oil man drilled and found gas up and down the line from Sapulpa to Stroud, and on the way down into Oklahoma as far as Chickasha. The Oklahoma Natural Gas Company laid lines and built compressor stations to serve this growing need for fuel. Then the Devonian Oil Company built a natural gasoline plant on the little creek across from one of the Oklahoma Natural Gas Company's stations, taking the gas from the "high line" and passing it through its plant. This gas is more or less rich in gasoline, and oftimes less rich, for it is comparatively dry gas. They take this gas from the high lines through convenient by passes, where it is metered through to the absorbers, which are eight in number, and then passes back into the line leading to a nearby compressor station of the Oklahoma Natural Gas Company. The pressure is carried around 350 pounds, and necessitates high pressure outside piston packed pumps for the mineral seal circulation.

You can see in the accompanying pictures how pleasing it is to walk through the yard of this plant, for a vista of zinnias, marigolds, cannas and a velvety lawn will greet you as soon as you pass through the large, airy, comfortable office. You can see the little "bird cage" which houses their psychrometer, for the Devonian people are careful operators, and watch their temperatures. Their loading rack is also handily located, close enough for the operator to take care of. The guy wires on the various tall structures, have the turnbuckles polished, oiled and wrapped with duck, then painted to preserve the threads.

The mineral seal is trapped out of the absorbers through liquid level controls to a vent tank, thence through their exchangers to the horizontal steam still.

One John C. Albright, natural gasoline plant operator in the Greater Seminole area of Oklahoma, in driving past the Kellyville, Oklahoma plant of the Devonian Oil Company, was so struck with the beauty of the spot where the plant is located, the symmetry of plant layout, and the well kept appearance of visible equipment that he stopped for a visit with C. C. Woodson, in charge of the plant.

The Kellyville plant of the Devonian Oil Company is located on the highway between Sapulpa and Bristow, and many natural gasoline men driving through this section have visited, or been tempted to visit, this orderly installation. And, let it be said, visitors are always welcome on the Devonian properties. It was through the assistance of C. C. Woodson, plant superintendent, and E. S. Calvert, general superintendent, that the detailed descriptive article of this company's Osage Plant No. 3 was secured for publication in the February, 1928, issue of THE REFINER AND NATURAL GASOLINE MANUFACTURER.

John Albright, incidentally, is the author of the article "Temperature Control Increases Gasoline Plant Efficiency," September, 1929, issue of this magazine, page 60. John has been operating gasoline plants in Texas, New Mexico and Oklahoma since 1920.

With a little over 600 words and two photographs, J. C. A. tells a great deal about the Kellyville plant of the Devonian Oil Company.

GEORGE REID.

Tentative Specifications of Apparatus and Test Procedure for Determining the Specific Gravity of Gases

Effective January 1, 1930, and thereafter for one year; becoming a permanent standard January 1, 1931, unless otherwise modified or amended by official action of the Natural Gasoline Association of America.

Foreword

The specific gravity of gases shall be determined by means of a gas balance constructed, as to principle, similar to the Edwards gravity balance described in Technologic Paper No. 89, United States Bureau of Standards. This principle embodies Boyle's law which prescribes that the density of a gas at constant temperature is proportional to its pressure; or restating this law as quoted in the technologic paper referred to, "the densities of two gases at normal pressures are in inverse ratio to the pressures when of equal buoyant force."

Apparatus

1. *Balance.*

The balance to be used shall consist essentially of a balance beam with its supporting fulcrum mounted inside a gas-tight, cylindrical metal case. The balance beam shall have a light, sealed globe, made of a substantially inflexible material, attached rigidly to one end and an adjustable counter-weight on the other.

The beam fulcrum shall be a support, described by the Bureau of Standards as a modified Cardan suspension, as illustrated in Figures 1, 2 and 3, and as now further defined. In this construction, four metal strips, fixed rigidly at A, Figures 1 and 2, are attached securely to parts B which are in reality a part of the balance beam.

The vertical distance between the bottom plane of part A to the top of the plane of part B shall be between 18 and 20 mm. The distance across the top of B as seen from the side, (Figure 1), shall be the same as the vertical distance between A and B.

The horizontal distance, as seen from the side, (Figure 1), across the lower face of part A where the suspension strips are fastened shall be about 0.1 mm.

Since this suspension acts as though the center of motion is on a horizontal line passing through the bottom of A, as seen in Figure 2, the center of gravity of the beam including the center counterweight G should be on this line. Therefore, the horizontal line H, (Figure 2), passing through the center of the beam should be 2 mm. below the bottom of A.

The suspension strips, C, shall be of phosphor bronze, one-eighth of an inch wide and one-thousandth of an inch thick. (If in practice it is found that strips of greater strength are desired, strips 0.0015 inch thick may be used. This should be the maximum thickness.)

A small pin, K, shall be permanently fastened in B at each point where a strip, C, is clamped. Each pin should be approximately perpendicular to the face in which it is fastened and should be located near the lower end of the vertical line passing through the center of the lower plate D. Each of these fastening plates, D, on B, are provided with a hole into which the pin projects. The hole in the plate, D, on the side facing against B should be slightly countersunk in order to allow any burr which may be around the hole punched in the strip and which otherwise would prevent the plate from pressing uniformly against the strip, C. A small hole shall be punched in each suspension strip, C, several millimeters from the end just large enough so that the strip may easily fit over the pin, K. These pins are for the purpose of holding one end of the suspension strip when it is being mounted. There are no pins in A. The faces of A and B and of the plates, D, which clamp the strips shall be machined flat and smooth so that the strips, C, will be held firmly in place.

The plates, D, shall be held tight by means of two screws each. These screws shall be of such size that they may be turned up quite tightly without danger of stripping the threads or breaking off.

Two spacers of a height equal to the selected vertical distance (18 to 20 mm.) between the lower plane of A and the upper plane of B are to be provided with each balance, with a place to hold them when not in use. These spacers should be in the nature of pins of round cross section and the two should be machined to identical length. The spacers are for the purpose of adjusting the distance between A and B when new strips are being mounted. Sufficient space on A and B to insert these spacers shall be provided at the outside of each set of suspension strips.

Some device, such as that shown in the diagrams, shall be provided for raising the beam approximately 2 mm. and locking the beam securely so that the balance may be safely transported without damage to the mechanism.

The gas-tight, cylindrical case, called the gas chamber, shall be of such dimensions as to easily accommodate the beam mechanism and allow amply for its necessary movement. The sealed globe, or bulb, shall be approximately ellipsoidal in shape with its long axis approximately 20 cm. and its short diameter about 12.5 cm. and should weigh not more than 1.5 lbs. The length of the beam, including the bulb, M, on the one end and the scale, J, on the other should be approximately 48.5 cm.

The sensitivity of the balance shall be, by means of the center counterweight, G,

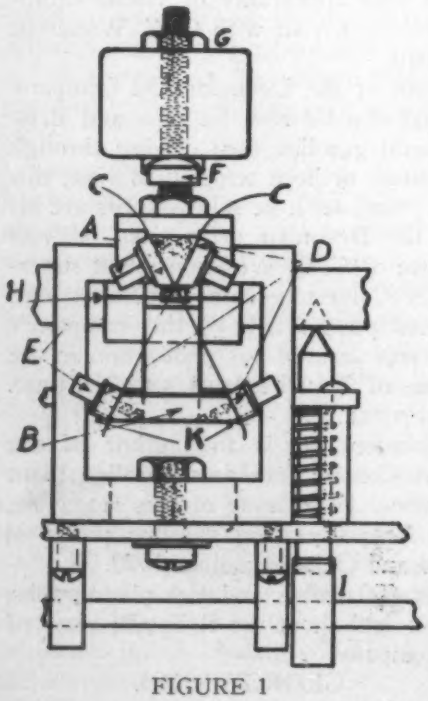


FIGURE 1

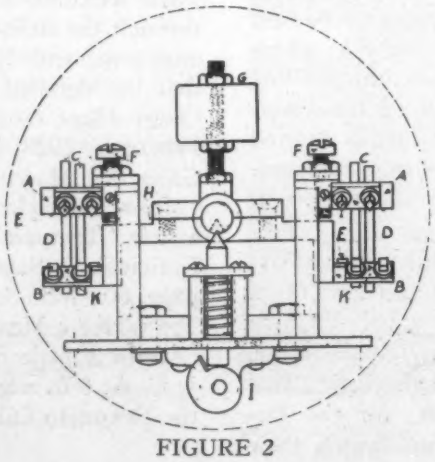


FIGURE 2

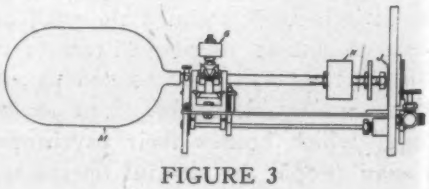


FIGURE 3

Vogt

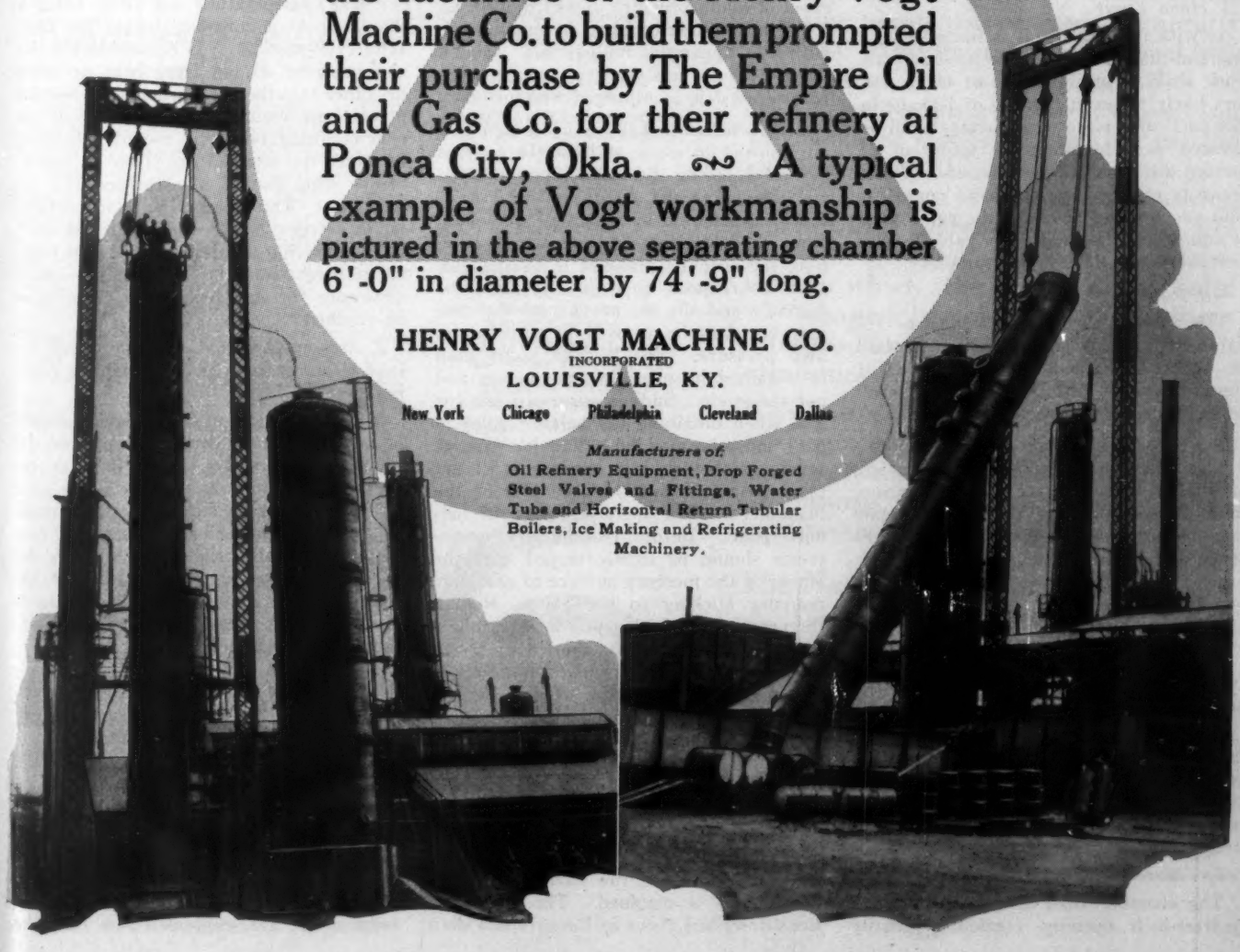
Stills For Empire

Confidence in riveted vessels and the facilities of the Henry Vogt Machine Co. to build them prompted their purchase by The Empire Oil and Gas Co. for their refinery at Ponca City, Okla. ∾ A typical example of Vogt workmanship is pictured in the above separating chamber 6'-0" in diameter by 74'-9" long.

HENRY VOGT MACHINE CO.
INCORPORATED
LOUISVILLE, KY.

New York Chicago Philadelphia Cleveland Dallas

Manufacturers of
Oil Refinery Equipment, Drop Forged Steel Valves and Fittings, Water Tube and Horizontal Return Tubular Boilers, Ice Making and Refrigerating Machinery.



adjustable to such degree as to permit an appreciable displacement of the beam for pressures, expressed in a change of mercury levels, equivalent to 0.500 mm. in each arm of the balance manometer.

The beam scale, attached to the end of the beam, shall be graduated in millimeters and a fine cross hair shall be fixed as a reference in the front head of the gas chamber. The gas chamber shall be equipped with a suitable device for distributing the entering gases in such manner as to prevent any solids or liquid droplets, entrained in the gas, from impinging on any part of the beam mechanism.

It must be recognized that the balance is an apparatus of high sensitivity and the construction of the mechanism, therefore, must be of highest quality.

The gas balance and all appurtenances used for this test shall be absolutely free from leakage.

2. *Manometer.*

The manometer used in determining gas pressures within the gas chamber shall be equipped with scales of thin material graduated in millimeters. The scales shall be mounted in front of the mercury columns and shall extend over the tubes to their centers, thus easily affording accurate readings.

The manometer shall be provided for rigid attachment so that the mercury columns will be perpendicular.

3. *Hand Pump.*

As with the balance, it is likewise very essential that the hand pump used for this work shall be entirely free of leaks. Errors likely to result because of leakage in this particular piece of apparatus shall be reduced to a minimum by soldering or tinning all connections. Because of the necessity of operating the hand pump for both vacuum and pressure, the pump shall be equipped with a four-way valve to prevent contamination of gas samples.

4. *Barometer.*

The aneroid barometer shall be of reliable manufacture. This instrument shall be checked frequently and adjusted if found to be in error. Barometers shall be calibrated in millimeters.

5. *Balance Mounting.*

The balance may be operated from any substantial support free from vibration, in such position that the balance scale may be read with accuracy. In the absence of any other convenient supporting base a tripod should be used for mounting the balance.

6. *Hose and Valves.*

All hose used shall be of the thick-wall rubber, pressure-vacuum type and free of any leak.

Only needle valves shall be used on the hose lines. In making the test, it is essential that, as required pressure is approached, it can be gradually and easily increased or decreased, and the valves used must permit of such adjustments.

7. *Thermometer.*

The chamber shall be provided with a quarter-inch opening (sealed ordinarily with a plug or a valve) into which may be secured and tightly fitted, as required, a thermometer for determining gas temperatures within the chamber.

Test Procedure

1. All hose or connections required for the test shall be connected before the test is actually started and the balance shall then be securely mounted and leveled. This precaution must be taken to eliminate, after the test has started, disturbances tending to jar the apparatus and thus introduce errors because of indeterminate changes in the position of the beam.

2. The beam weights shall now be adjusted by trial so that the beam will balance in air at a pressure not greater than atmospheric and in the gas at a pressure not greater than the pressure on the line from which the gas sample is obtained. The utmost care must be taken in adjusting the beam weights. The beam must be secured by the locking device when such adjustments are made so that the beam suspension may in no way be strained or damaged. See that the weights and nuts are tight.

3. The gas chamber and all connections shall now be evacuated to an absolute pressure of not more than 130 mm. of mercury (approximately 600 mm. vacuum), by means of a vacuum pump and with all hose connections closed, the apparatus shall be tested for leakage. Any exact absolute pressure of not more than 130 mm. of mercury shall be maintained, with the apparatus undisturbed, for an interval of not less than two minutes, before the system is adjudged without leaks.

4. The balance shall be avacuated and air allowed to enter at least three times before observing the balance pressure for air. To purge the apparatus the procedure of evacuation by means of a vacuum pump shall be adopted. For each evacuation, the absolute pressure in the balance shall be reduced to within 130 mm. of mercury and the air or gas, as the case may be, shall be allowed to enter at its own pressure. The balance point shall be obtained by operating the valves and not the pump. Sudden surges of air (or gas, when obtaining the balance point in gas) must be avoided. The increase of pressures should be in increments of not more than 0.50 mm. in each arm of the manometer when operating near the balance point. Before reading, the manometer should be lightly tapped with the finger at the mercury surface to eliminate mercury sticking to the glass. Record the pressure on the balance, as determined from the manometer, as the balance point for air. Make a check determination to obtain a second reading of the balance pressure. The barometric pressure should be observed and recorded at this time. All barometric readings shall be made with the barometer at rest in the same position throughout the test.

5. Similarly, the balance shall be evacuated and gas allowed to enter at least three times before the balance pressure of the gas is obtained. The manipulations described above in Paragraph 4 shall be repeated for obtaining the balance point in gas. Two determinations of the gas balancing pressure shall be made.

6. Finally, before dismantling the apparatus, the balance shall be purged a third time by evacuation, as instructed in Paragraph 4, for air, and the balance pressure in air again obtained and recorded. The barometric pressure shall again be observed at this time.

7. See that the beam mechanism is secured by the locking device after the test is completed.

Notes

1. The accuracy of the test shall be such that check determination of the gas specific gravity will agree within two units in the second demical place for wet gases, or gases having a specific gravity greater than 0.75, and within four units in the third decimal place for dry gases, or gases having a specific gravity less than 0.75.

2. Where accuracies expressed in the third decimal place are required, the use of a calcium chloride dryer in the air-suction line to the balance is recommended on warm days when the humidity is high.

3. Should any limitation of procedure herein incorporated be impractical or impossible because of any extraordinary conditions encountered, the parties cooperating in a test may agree to modify such limitations.

Precautions to Be Taken for the Test

1. The temperature of the balance should be kept constant during the test. Wherever possible, it is recommended the apparatus be shaded from heat or wind or other weather disturbances. Special precautions should be taken to avoid errors resulting from the use of a balance of which the temperature is not in equilibrium with that of the surrounding atmosphere. Reference is made in particular to extreme changes in conditions, such as in removing a balance, shaded in transit, to bright sunlight for the test without allowance for equilibrium temperatures to be reached.

2. Manometers and mercury shall be kept clean so as to permit accurate readings.

3. Condensation in the balance should be avoided. Small drops of liquid on the beam or float will give rise to large errors in the determinations.

4. Serious errors may result from readings taken with the balance beam at rest. This is especially true if there is any degree of friction in the operation of the balance. A travel range of from 6 to 16 divisions on the beam scale shall be maintained at the time reading are made.

5. All scale readings shall be made while the operator is in a position directly in front of the apparatus and with the level of the eyes held constant.

Calculation of Results

The specific gravity of a gas referred to air as unity may be represented as the ratio of the absolute pressure required for balancing the beam in air to the absolute pressure required for balancing the beam in the gas, expressed as a formula:

$$\text{SP. GR.} = \frac{A}{G}$$

where A = the manometer pressure plus (algebraically) the barometric pressure while the beam is balancing in air.

G = the manometer pressure plus (algebraically) the barometric pressure while the beam is balancing in gas.

The following examples illustrate the calculation of gas specific gravity from assumed test data:

ASSUMPTIONS OF TEST RESULTS

First Example	Manometer Pressure mm.	Barometer Reading mm.	Absolute Pressure mm.
Gas No. 1 (G_1)	—91 (vacuum)	736	645
Air No. 1 (A_1)	—1.0	736	735
Second Example			
Gas No. 2 (G_2)	+74	736	810
Air No. 2 (A_2)	—101 (vacuum)	736	635

From the first example, gas sample No. 1 would have a specific gravity determined as follows:

$$\text{Sp. Gr.} = \frac{A_1}{G_1} = \frac{800}{700} = 1.14$$

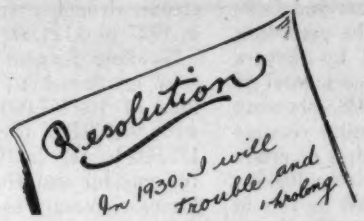
From the second example, gas sample No. 2 should have a specific gravity determined as follows:

$$\text{Sp. Gr.} = \frac{A_2}{G_2} = \frac{635}{810} = .784$$

Atlantic Seaboard Refineries More Active In 1928

An interesting report prepared by E. B. Swanson for the U. S. Bureau of Mines, reveals that the quantity of crude refined at plants on the Atlantic seaboard continued to increase during 1928, reaching a total of 170,506,000 barrels, as compared with 150,559,000 barrels in 1927 and 130,643,000 barrels in 1926. During each of the past two years the quantity of crude refined exceeded that of the preceding year by 20,000,000 barrels. Foreign crudes comprised 40 per cent. of the total throughput, as compared with 28 per cent. in 1927 and 22 per cent. in 1926. Foreign crude runs increased from 42,301,000 barrels in 1927 to 38,786,000 barrels in 1928, while domestic crude throughput registered a decrease of approximately 6,500,000 barrels. Crude capacities of Atlantic Coast refineries also showed a slight increase, being rated at 588,200 barrels daily at the end of 1928, as compared with 581,700 at the beginning of the year.

Gasoline production of Atlantic Coast refineries showed an average yield of 31.5 per cent., while gas and fuel oil production averaged 55.1 per cent. of the total crude run. The combination of increased foreign crude runs and decreased throughput of domestic crudes resulted in an increased production of gas and fuel oils and a decrease in the relative production of gasoline. Cracking operations accounted for 40.6 per cent. of the gasoline produced, as compared with 35.3 per cent. in 1927. Receipts of gasoline



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by tankers from the Gulf Coast and California ports increased over the preceding year. Receipts of crude oil by tankers from Gulf Coast ports reached a total of 92,745,000 barrels during 1928, showing progressive increases over similar receipts during preceding years. Receipts of crude oil from California dropped from 10,651,000 barrels in 1927 to 3,330,000 barrels in 1928. Pipe line deliveries of Mid-Continent crude also showed a marked decrease, dropping from 11,206,000 barrels in 1927 to 3,121,000 barrels in 1928.

Gasoline demand in the Atlantic Coast area continued to increase, reaching a total of 106,567,000 barrels, as compared with 98,329,000 barrels in 1927 and 88,177,000 barrels in 1926. Domestic demand for gas oil and fuel oil showed a small increase, mainly as a result of increased deliveries to steamships and a larger consumption of oil as fuel by refineries. The indicated demand for kerosene decreased from 10,156,000 barrels in 1927 to 9,166,000 barrels in 1928.

Additional valuable information is contained in this report which can be obtained by addressing the United States Bureau of Mines, Department of Commerce, Washington, D. C., requesting Information Circular 6187, entitled, "Sources and Distribution of Major Petroleum Products, Atlantic Coast States, 1928."

"Thermal Properties of Petroleum Products"

"THERMAL Properties of Petroleum Prodcts" is the title of an important work recently completed and now ready for distribution by the United States Department of Commerce, Bureau of Standards, Miscellaneous Publication No. 97. The compilation of all important existing information on the thermal properties of petroleum and petroleum products constitutes an important and valuable supplement to the technical literature for use by tecnologic research worwers, designing engineers and refinery operators. This publication, for the first time, presents practically all of the important work of a large number of investigators, including the Bureau of Standards, and covers in a concise yet thorough manner such matters as Thermal Expansion, Heats of Combustion, Specific Volume, Thermal Conductivity, Specific Heat, Latent Heat of Vaporization, and Heat Content.

The Bureau of Standards has received many requests for information on the thermal properties of petroleum products both from the petroleum industry and from other departments of the government. As the author, C. S. Cragoe, states, information of this sort is rarely to be found in systematic form so that appropriate values for a desired property may be readily assigned to the particular product in question. In fact, with the possible exception of the few technologists possessing their own systematic files, there has been no known previous compilation of such data. Engineering handbooks and physical and chemical tables are surprisingly deficient in this respect and the values given in such publications differ widely in many instances.

The Bureau of Standards has made no extensive experimental study of the subject as a whole, as Mr. Cragoe states in the Introduction of his work, but has had occasion during the past few years to make numerous determinations of some thermal properties of petroleum products in combination with other investigations carried on in the laboratories of the government.

In 1927 an investigation was undertaken on the thermodynamic properties of petroleum hydrocarbons, listed as Project No. 38 of American Petroleum Institute Research. In order to lay out an experimental program intelligently, it was necessary to make a critical study of the data available on the subject in the literature. The results obtained from this critical study when combined with unpublished results obtained at the bureau, including some preliminary results obtained under Project No. 38, appeared of sufficient technical importance to warrant the preparation of preliminary tables covering several of the properties which have been investigated experimentally. Because of the lack of published information in a form readily usable by the industry the tables have been prepared in engineering units.

The contents of Miscellaneous Publication of the Bureau of Standards No. 97, which is available from the Superintendent of Documents, price 15 cents, include the following:

Fundamental Units and Constants.

Thermal Expansion—

- Thermal Expansion of petroleum asphalts and fluxes.
- Thermal Expansion of volatile petroleum liquids.
- Thermal Expansion of gasoline-benzol mixtures.

Heats of Combustion—

- Heats of combustion of crude oils, fuel oils, and kerosene.
- Heats of combustion of volatile petroleum products.
- Heats of combustion of gasoline-Benzol mixtures.

Specific volume of vapor.

Thermal conductivity.

Specific heat—

- Specific heat of petroleum oils of various gravities.
- Specific heat of petroleum vapors.
- Specific heat of petroleum oils ot various gravities in Btu per gal °F.
- Specific heat of petroleum asphalt.

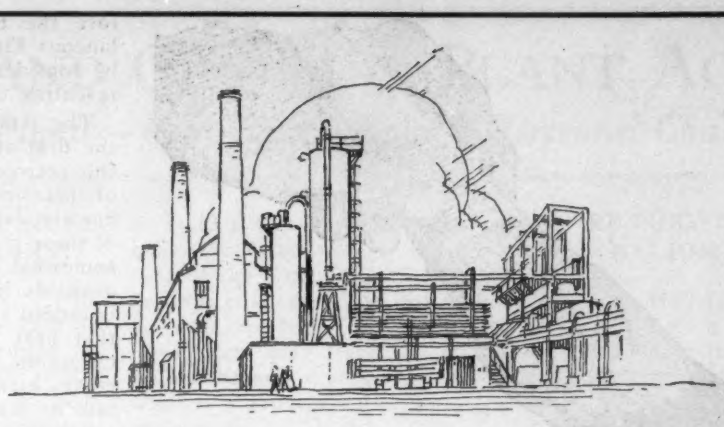
Latent heat of vaporization.

Heat content—

- Heat content of petroleum liquids.
- Heat content of petroleum vapors.
- Heat content of asphalt.
- Heat content of paraffin wax.

The author points out that most petroleum products consist essentially of a large number of different hydrocarbons which are so nearly alike physically that a mixture of them exhibits a thermodynamic behavior somewhat analogous to that shown by a mixture of isotropes. Experimental evidence indicates that many of the thermodynamic properties of mixtures of hydrocarbons are not seriously affected by considerable changes in composition. In fact, it has been found that many of these properties are very closely related to the density of the liquid, which is usually known or can be readily determined with a hydrometer. This relationship afforded a very useful means of correlating existing data on commercial products. By the same means a valuable check was obtained from data on pure hydrocarbons known to exist as constituent parts of these products. Although some consistent differences were found between data on paraffin and naphthene base products of the same density, these differences were small and, consequently, of little significance in practical applications of the data. It must be realized, the author states, that values for the properties of petroleum products, which are subject to considerable variation in composition, can not be assigned with the same degree of accuracy as can be done in the case of materials which have a definite composition.

In conclusion the author states that it is fully realized that the experimental data on several of the properties included in the discussion is not as complete as could be desired and that a revision of the tabulated data may be rendered necessary by additional experimental work, such as that recently undertaken on "The Thermodynamic Properties of Petroleum Vapors," listed as project No. 38 of the American Petroleum Institute Research. There-



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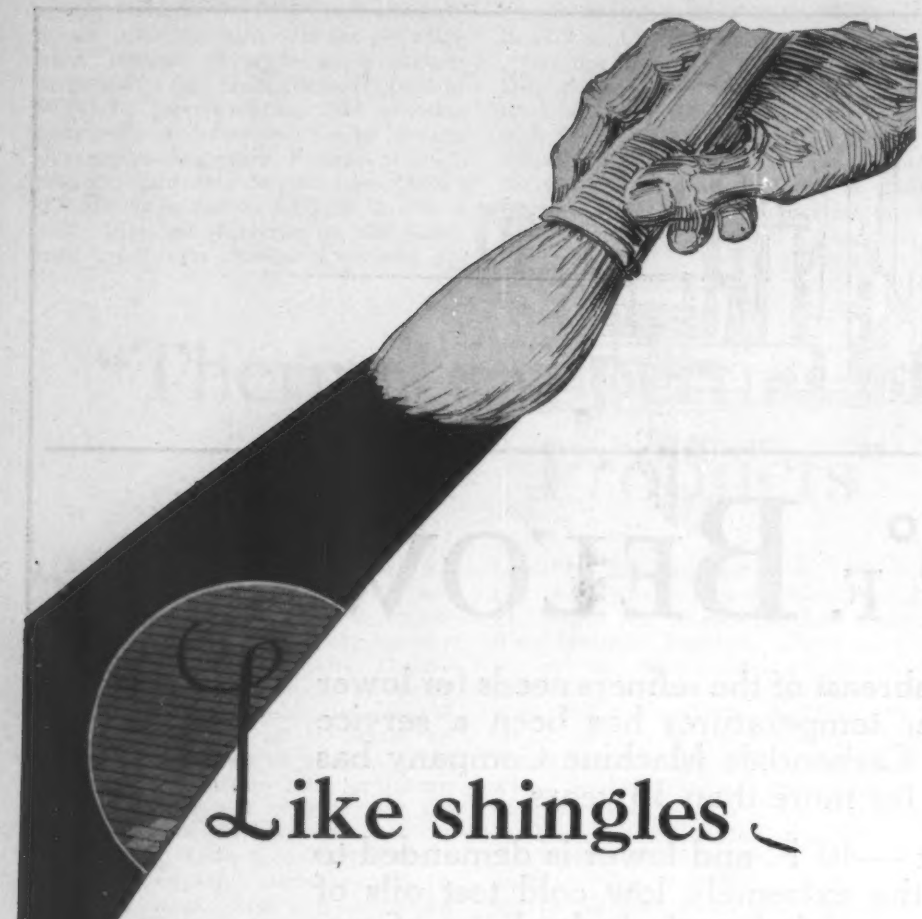

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fore the tables presented in Miscellaneous Publication No. 97, are not to be considered as final, but as best representing the present knowledge.

The bulletin as prepared represents the first attempt ever made to supply the petroleum industry and the users of petroleum products with comprehensive data on the thermal properties of these products in readily useful form somewhat analogous to the tables now available on steam and ammonia. This is indeed surprising when it is recalled that heat is involved, almost without exception, in all of the numerous processes used to convert crude petroleum into its many products. Tables of the properties of steam and ammonia, based largely on the extensive work and researches of Regnault, were available to mechanical and refrigerating engineers nearly 50 years ago. Those tables played no small part in the progress and development of these two branches of engineering. The importance of such tables in engineering is reflected by the elaborate researches conducted on steam and ammonia in recent years, primarily to extend the range and accuracy of the tabulated data.

The petroleum industry has been less fortunate. It has had no analogous tables to point the way toward advancement in processes and in design of equipment. If the petroleum industry in the last 25 years of its astounding growth, had possessed as much information on the thermal properties of its fluids as was made available on steam and ammonia by Regnault in 1862, the economic saving in more efficient methods and apparatus would probably have amounted to an appreciable fraction of the total value of its products.

Miscellaneous Publication of the Bureau of Standards, No. 97, contains the results of a critical survey of existing data which was undertaken as a preliminary step in an investigation on "The Thermodynamic Properties of Petroleum Hydrocarbons," project No. 38 of the American Petroleum Institute Research. Financial assistance in this work has been received from a research fund of the American Petroleum Institute donated by John D. Rockefeller. This fund is being administered by the institute with the cooperation of the Central Petroleum Committee of the National Research Council.

Sidney F. Heckert, president of the National Fire Proofing Company, Pittsburgh, has just been elected president of the Eastern Hollow Building Tile Manufacturers Association.

This association has its headquarters at 420 East 23rd Street, New York City, and is composed of the leading manufacturers of structural clay products on the Eastern Seaboard.

Heckert, at this time, is also serving as president of the Structural Clay Tile Association of Chicago, the national organization in that industry, with which body, however, the eastern manufacturers are not affiliated.

REFINERY AND GASOLINE PLANT ACTIVITIES

New Plants – Construction Notes – Personnel Changes

AMERICAN DESIGNED REFINERY OPERATING IN GERMANY

EBANO Asphalt Werke, A. G., of Hamburg, Germany, a subsidiary of the Pan American Petroleum & Transport Company, was recently placed in operation in the production of high grade asphalt products for distribution in Central Europe. This American designed and constructed refinery is operating on Ebano crude oil from Northern Mexico which is produced on Pan American properties. This crude is about 75 per cent pure asphalt, practically free of paraffin. The products are prepared for paving work and such special utilization as roofing papers, and the like.

The refinery construction work consisted of the erection of two 3000 barrel vacuum distillation units and such auxiliary equipment as crude storage facilities, ocean ship unloading dock, finished product storage, light distillate storage, power house, barge loading dock, storage and filling house for finished special grades of asphalt, railroad service trackage, roads about the plant yard, and steam, air, water and fire protection lines, laboratory and office buildings.

The new plant is located on the South Elbe River at Harburg, a suburb of Hamburg. This territory is restricted by the German government which has close control of the location of industrial installations. The Prussian government controlled a large tract of land along the South Elbe river and has for a period of years been developing this territory for industrial plant sites by dredging and filling in with sand to a height which is above high water level at all times. The site of the Ebano Asphalt Werke is part of a section set aside as a petroleum base. The Dutch Shell interests have a refinery directly across from the new American owned asphalt works.

As the refinery site was filled to a depth of about 15 feet it was necessary that all foundations be carried on piles. Precast square piles of concrete about 50 feet long were used throughout the plant. The entire project, including preparation of the foundations and extending to the last detail in completion of the plant ready to be operated was erected by Arthur G. McKee & Company who drew up plans and specifications in cooperation with the Pan American Petroleum & Transport Company.

As the crude is required it is charged to the two 3000 barrel vacuum units. These retorts together with the fractionating equipment process the crude under vacuum to produce nine grades of asphalt. The softest grade will require the distillation of about 25 per cent of the crude, and for the hardest grade it is necessary to distill about 50 per cent overhead. All grades are finished when they leave the distillation equipment and are conducted to their respective storage tanks provided for each grade.

Since these asphalt materials must be kept hot to keep the product in fluid state, all storage tanks for the finished product are insulated on sides and roof to conserve the heat of the products as they leave the stills. In addition all such tanks are provided with steam coils for heating purposes.

In addition to the nine grades of asphalt, two oxidizing stills were installed, of 600 barrels capacity each. These are employed in making air-blown asphalt. For some special purposes it is desirable to have oxidized asphalt, and this equipment is sufficient at present to meet the demands of the trade.

The power house consists of three boilers having a rated capacity of 300 horsepower each and are similar to the Babcock & Wilcox type. They are fired with coal, employing chain grate stokers. Pulverized coal is employed in the firing of the distillation units, which also use stokers. This type of firing is economical in Germany because of the existing tariff which places a high duty on fuel oil or light petroleum distillates. The dividing line between dutiable and non-dutiable oils entering Germany is that any oil lighter than water or having a specific gravity less than 1, is dutiable.

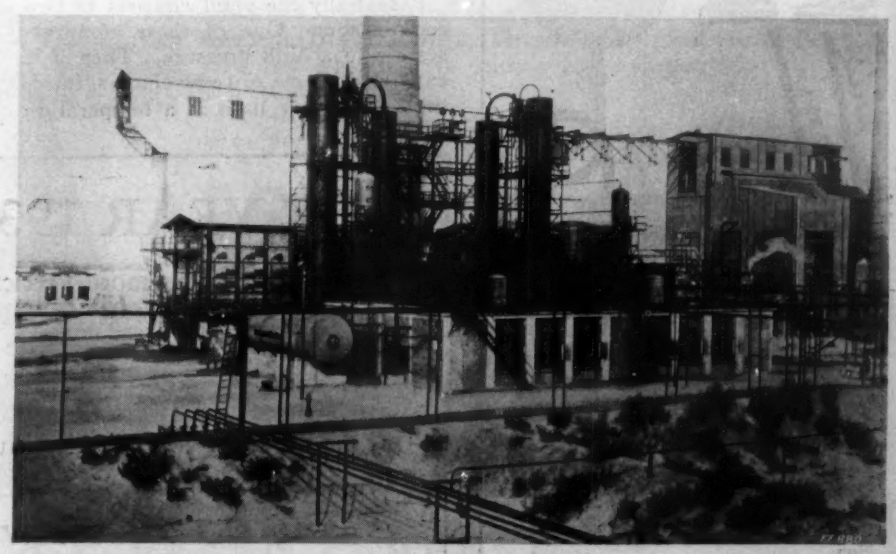
RE-PURIFICATION OF PORTABLE HELIUM PLANT PERFECTED

A HELIUM re-purification plant of a mobility hitherto unattained has been designed, constructed and shipped by The Helium Company of Louisville, Kentucky, to the Goodyear-Zeppelin Corporation, Akron, Ohio.

Despite its small size (it is mounted on a pneumatic-tired trailer body and can cover any terrain a truck can negotiate) it has an efficiency equal to fixed plants and capacity to purify 1500 cubic feet of gas an hour. The advantages of such a plant are apparent. It can be drawn to the side of an airship or a blimp. There it will withdraw the impure gas, purify it and discharge it to any desired point at any pressure to 2000 pounds per square inch. The job done, the plant can be moved at once to the next ship.

Other portable plants in existance have their mobility limited by reason of the fact that they are mounted on railroad cars.

Although The Helium Company was not organized for such work—its business is the manufacture and marketing of helium gas—as a matter of policy it does lend its engineering skill and experience to any job that will further the development of lighter-than-aircraft. Goodyear-Zeppelin's need for a portable plant is one instance. Another arose on the occasion of the Graf-Zeppelin's first trip to the United States. Before the flight could start an obstacle had to be overcome. A supply of fuel gas for the great Maybach engines had to be at Lakehurst when the Graf landed. But the right



Modern American built refinery at Hamburg, Germany operated by Ebano Asphalt Werke, a subsidiary of Pan American Petroleum & Transport Company

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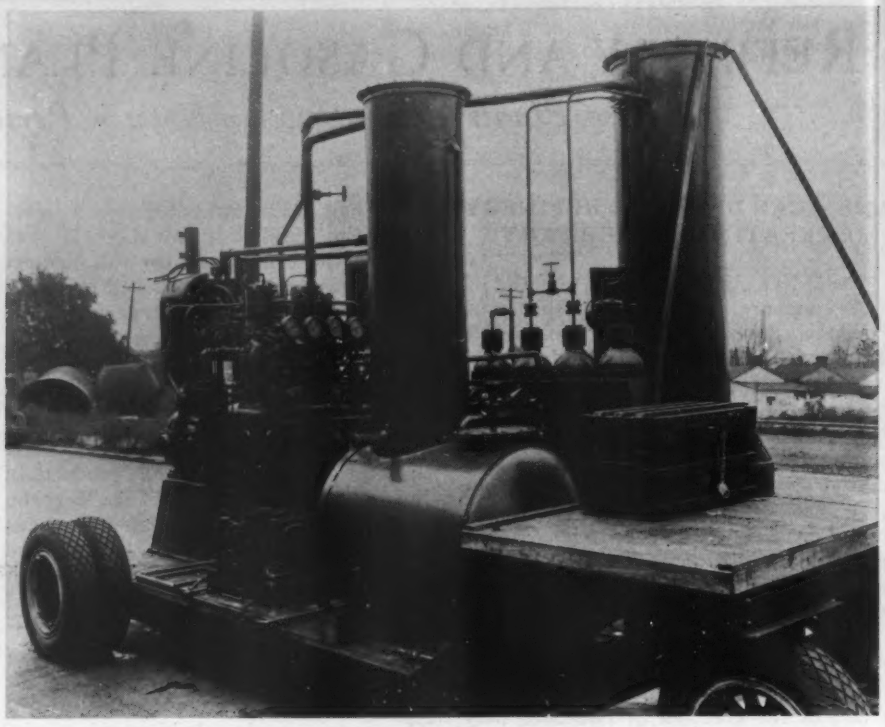


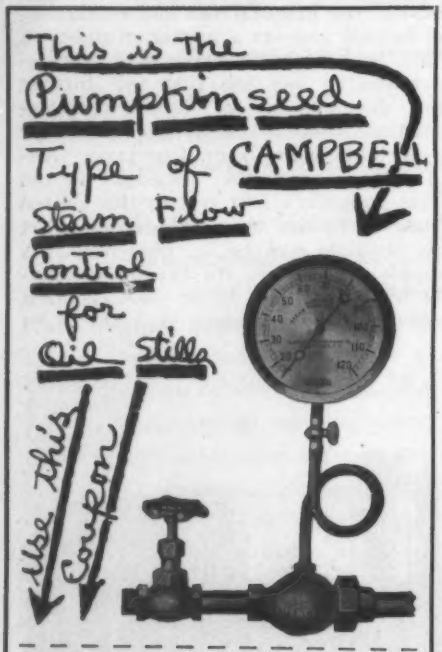
First portable helium repurification plant now in service

fuel gas was not available in this country so the Navy Department appealed to industry. No other company would undertake to furnish the fuel gas except The Helium Company. Specimens of a fuel gas it immediately developed were submitted to the Navy Department and accepted. When the Graf reached Lakehurst its fuel gas was waiting. Without the gas the trip could not have been attempted.

The men who developed the fuel gas also designed the re-purification plant. They are R. R. Bottoms, director of research for The Girdler Corporation, which operates The Helium Company, and E. G. Luening, executive vice president of The Girdler Corporation and head of its engineering department.

Essentially the plant consists of two compressors. One of these compresses air to a high pressure. Then it is expanded in one of two columns, forming a liquid air bath at a temperature of 310° below zero. The second compressor brings the helium to a high pressure and passes it through a series of intricate copper coils in the column. The copper tubing used is almost half a mile long. Thereupon the helium is submerged in the liquid air bath and the reduction in temperature under pressure liquefies out the impurities. These are drawn off and the helium, now at 98 per cent purity, is passed into the containers under the desired pressure.

The plant will mean a saving in time and money. It can be sent at once to any ship whose helium has reached a grade of 80 per cent. purity. The loss in re-purification is only about one per cent. and, therefore, the helium can be used again and again. Such a saving is possible with helium only. Hydrogen, when it becomes impure, is dumped. Its combustibility makes re-purifying hazardous.



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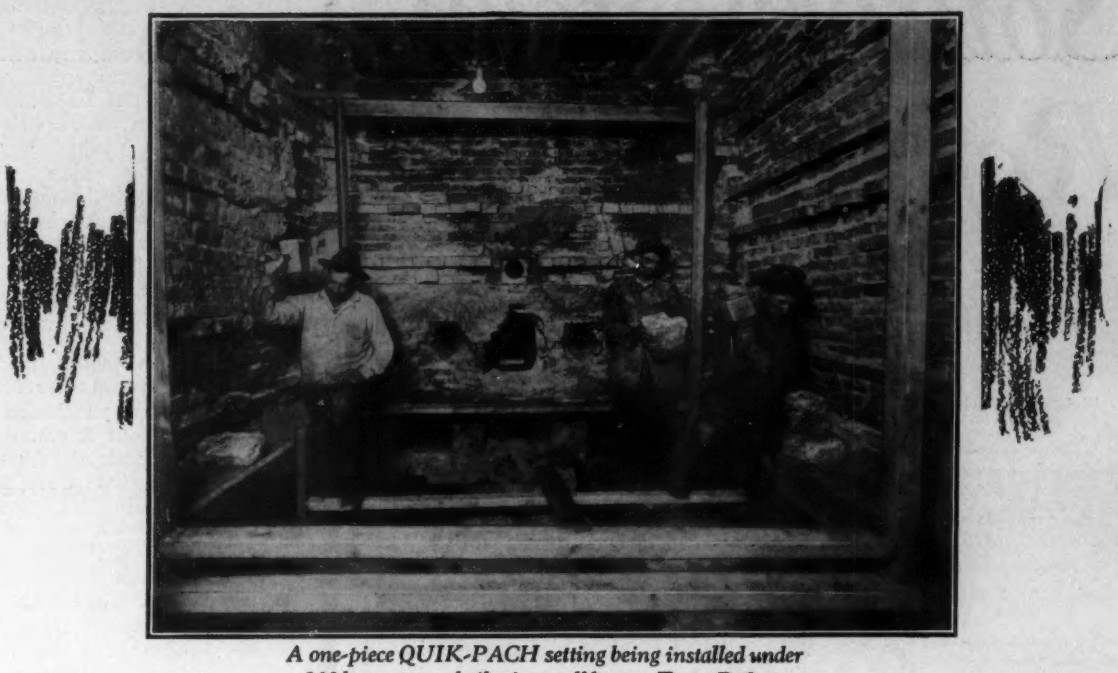

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STANDARD OF NEW YORK BUYS WHITE EAGLE

Official confirmation of the sale of the properties of White Eagle Oil & Refining Company to Standard Oil Company of New York was announced late in December by L. L. Marcell, chairman of the board of directors of the White Eagle organization. January 27, 1930, the stockholders of the White Eagle company will be asked to approve an exchange of 10 shares of White Eagle Oil & Refining Company for 8½ shares of Standard Oil Company of New York.

Through acquisition of the White Eagle properties Standard Oil Company of New York becomes a direct competitor to Standard Oil Company of Indiana. Three refineries with a total capacity of 18,000 barrels daily, and 4000 barrels production in Kansas, Oklahoma, and Texas, and extensive marketing facilities in the Middle West and Rocky Mountain sections, are included in the purchased properties. White Eagle Oil & Refining Company is to be reorganized as a subsidiary of the Standard Oil Company of New York, it is said.

Little change in management will be made, and L. L. Marcell, organizer of the White Eagle company will become a director of Standard Oil Company of New York. R. R. Irwin, president of White Eagle Oil & Refining Company will continue to head the subsidiary company. This purchase gives the Standard Oil Company of New York a third strong subsidiary company. The company at present controls General Petroleum Corporation, operating on the West Coast, and Magnolia Petroleum Company, operating in the Southwest.

EMPIRE AND WOLVERINE MERGE

A holding company, to be known as the Wolverine-Empire Refining Company has been organized to take over the stock of Empire Oil Works, Oil City and Tidioute, Pa., and the Wolverine Lubricants Company of New York. This includes the Todioute Refining Company, which was taken over by the Empire Oil Works in July, 1928.

Offices of Wolverine-Empire Refining Company will be in New York. The officers are E. W. Chase, chairman of the board; C. H. Ellingwood, president; F. W. Baer, treasurer, A. W. Scott, secretary; and F. S. Smith, assistant treasurer.

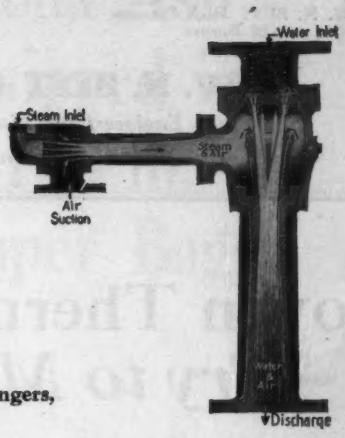
Wolverine Lubricants Company is a large distributor of lubricants on the East coast and operates a compounding plant at Reno adjacent to Empire Oil Works refining plant. Each company will retain its identity and operate as in the past.

SHELL OIL COMPANY TO ERECT NITROGEN FIXATION PLANT

Shell Development Company, subsidiary to Shell Oil Company, California, has purchased 135 acres near Long Beach, California, which forms the nucleus of a proposed $5,000,000 nitro-

S & K HYDRO-STEAM AIR PUMPS
operate without inter-or after-condensers

The multi-nozzle steam jet primary discharges directly into a multi-nozzle water jet secondary stage which in turn discharges to atmosphere. The discharge water can be used for cooling boxes or for other purposes.



Five std. sizes, all built for high vacuum work.

Four other types, single, double and triple stage.

Bulletin 5-H gives complete information.

The S&K line includes condensers, valves, spray nozzles, heat exchangers, gear pumps, etc., for the oil industry.

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The heavy nosing bar defines front.
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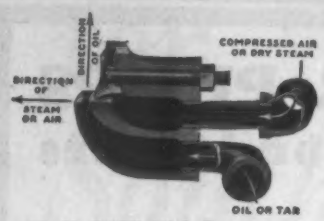

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Proven Thermix Advantages — —*Try to Match Them*

The Thermix Plate-type Air Heater is particularly applicable to oil still work for the following reasons:

Its plates are flat steel sheets direct from the nearest rolling mill and require no welding, riveting, flanging, machining or other fabrication.

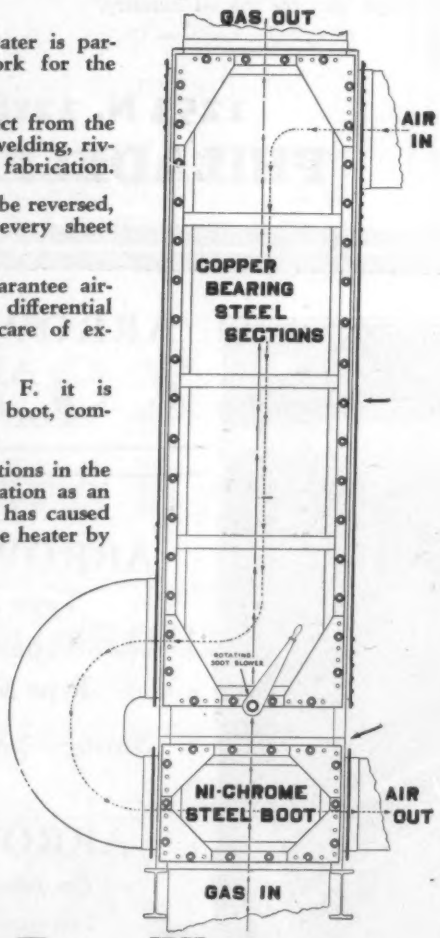
If accidentally damaged, they can be reversed, or replaced with flat sheets—and every sheet mill is a source of supply.

Its construction permits us to guarantee air-and-gas-tightness up to 20″ w.g. differential pressure, as it automatically takes care of expansion and contraction.

For temperatures above 1000° F. it is equipped with a nickel chrome steel boot, composed of welded removable sections.

There are many successful installations in the oil refinery field, and its high reputation as an Air Heater for the past eight years has caused its adoption as the standard plate-type heater by the largest boiler manufacturer.

For full information, mail the coupon or write for catalog T-18.



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gen fixation plant. Shell Oil Company has successfully negotiated for American rights to German patents covering a process which extracts nitrogen from the air for agricultural fertilizer and industrial chemical purposes. The plant is to be electrically operated. Construction on the first unit, to cost $250,000 is to begin at once, with additional units to be added as conditions warrant.

LICENSE HYDROGENATION PROCESS

Through its arrangements with the I. G. Farbenindustrie A. G.—Germany for participation in patents on hydrogenation, the Standard Oil Company of New Jersey, becomes the leader of a new Standard-I. G. Company which was formed for the development of mutual patent interests.

The American Company will have control and responsibility for management as is indicated by the officers recently chosen: F. A. Howard, head of the Standard Oil Development Company is president; E. M. Clark, vice president; M. H. Eames, secretary; R. P. Resor, treasurer; and as additional directors, Walter Duisberg, R. T. Haslam, Peter Hurll, H. A. Riedman, H. G. Seidel S. A . Shaw, Otto Von Schrenk and Guy Wellman.

With the experience gained at the partly completed plants at Bayway, New Jersey, Baton Rouge, Louisiana, and Baytown, Texas, and the I. G. Farbenindustrie plant at Mersburg, Germany, it is hoped to make the process available by licesne over a large territory and to exert a new constructive influence on the petroleum refining industry as a whole through this new technical achievement.

CARBON BLACK EXPORT ASSOCIATION FORMED

Representatives of companies producing more than 92 per cent of the world production of carbon black have formed the Carbon Black Export Association, Inc., a Delaware corporation formed under the Webb-Pomerene law, to promote the rapidly growing interests of American carbon black manufacturers in foreign markets.

Those participating in the formation of the export association were Binney & Smith Company, representing Columbian Carbon Company, Coltexo Corporation, Keystone Carbon Company and Texas-Louisiana Carbon Black Company; United Carbon Company, including its subsidiaries, Kosmos Carbon Company, Eastern Carbon Black Company and Crystal Carbon Company; Godfrey L. Cabot, Inc., including Texas Elf Carbon Company, Cabot Company, Cabot Carbon Company and Gas Products Company; J. M. Huber, Inc., including J. M. Huber Company of Louisiana, Inc., Ebony Carbon Company, Weston Carbon Company, and J. M. Huber Pigment Company; Palmer Gas Products Corporation, representing the associated carbon black interests of the Palmer Corporation and Electric Bond & Share Company; and

Waterous Rotary Pumps

Long Life . . . . *plus*

Almost a half century of experience goes into the making of the Waterous Rotary Pump. Little wonder the Waterous is well-known for its dependability!

In the Waterous you are assured of long life-plus: Smooth operation, accessibility, high efficiency and rugged construction.

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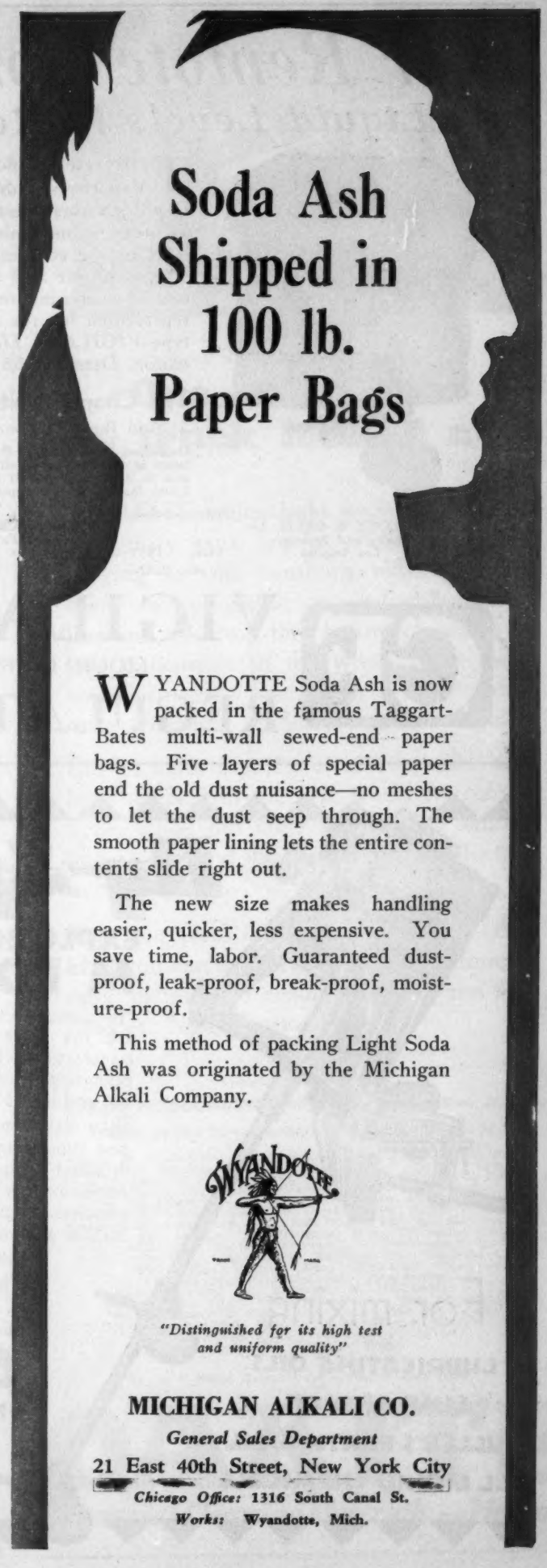

Soda Ash Shipped in 100 lb. Paper Bags

WYANDOTTE Soda Ash is now packed in the famous Taggart-Bates multi-wall sewed-end paper bags. Five layers of special paper end the old dust nuisance—no meshes to let the dust seep through. The smooth paper lining lets the entire contents slide right out.

The new size makes handling easier, quicker, less expensive. You save time, labor. Guaranteed dust-proof, leak-proof, break-proof, moisture-proof.

This method of packing Light Soda Ash was originated by the Michigan Alkali Company.

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"Distinguished for its high test and uniform quality"

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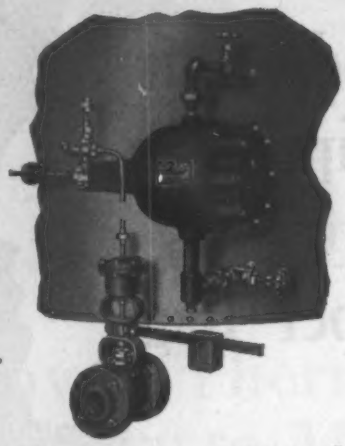
For Remote Control
of Liquid Levels in Refining



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Hy-Speed
EXPLOSION-PROOF MIXERS

Hy-Speed Portable Electric Mixers are the most efficient machines manufactured for blending, compounding, mixing or agitating all oils and liquid chemicals.

They clamp to any tank or vat in one minute and produce a more thorough, rapid mix . . . . more economically than by any other process. Capacities from five to 50,000 gallons.

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For mixing
LUBRICATING OILS
LIME AND OIL
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ALL LIQUID CHEMICALS

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R. W. Greeff & Company, representing Texas Carbon Industries.

The officers of the association are Norman Lee Smith, president; Edmund Billings, vice president, R. H. de Greeff, secretary, G. A. Williams, treasurer and H. W. Huber, assistant treasurer. These officers with John W. Herron of Palmer Gas Products Corporation constitute the board of directors.

NEW FRACTIONATING EQUIPMENT

Waverly Oil Works Company has completed plans for the early installation of five new modern bubble type fractionating columns to be erected at its Pittsburgh plant. The columns are the design of Dr. E. H. Leslie who has designed a large number of columns recently for use in refineries in the Appalachian refining district. Dr. Leslie is now doing consulting work.

GULF TO BUILD REFINERY

Gulf Refining Company has completed work on its new 2,000,000-barrel storage and distributing station on Staten Island, New York. This plant is employed as a depot to handle large shipments of petroleum products and crude. The plant consists of 24 tanks of 80,000 barrels capacity, and pipe lines and pumping facilities. A wharf 345 feet in length is provided. It is reported that as soon as railroad facilities are made available at this site the company contemplates the erection of a new refinery, although complete details of the project have not yet been announced.

OPERATING WICHITA FALLS PLANT

After remaining shut down for several months, Texman Refining Company is operating its refinery at Wichita Falls, Texas. Present crude runs are about 2500 barrels daily. This plant was formerly owned by Miller Petroleum Company. It has recently been rebuilt and a new pipe still erected. The plant is provided with Cross cracking facilities.

The White Star Refining Company at its new Trenton plant, near Detroit, Michigan, is now installing a complete lubricating oil department. This plant has a crude capacity of 6000 barrels daily. It was completed and placed in operation during the summer of 1929.

GULF REFINING COMPANY ENLARGING CRACKING DEPARTMENT

During 1930 Gulf Refining Company plans to increase cracking facilities at its Port Arthur, Texas refinery. Recently the company has ordered 32 large high pressure cracking stills from A. O. Smith Corporation of Milwaukee. This order totals about $1,000,000.

Gulf Refining Company has also contracted for two large vacuum pipe still units for installation at Port Arthur.

FORGED SEAMLESS
from a Solid Billet of Steel

Taylor Nozzles have become standard for all boiler and pressure vessel work. Taylor Nozzles are—

ECONOMICAL
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READILY AVAILABLE
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One hour later this truck looked new!

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But an hour after the Oakite solution had been applied to the first truck, its colors again stood out clear and bright, almost like new. And the paint was not affected in the slightest.

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Refine your distillates with liq. SO_2 and avoid

Inferior finished products

Treating losses

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Loss of valuable constituents in the distillates

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GAS BURNERS

Flame Burners
Short Flame Burners
Flameless Burners

Special Burner for Gasoline Plant and Refinery work.

Burns the richest of gas with a short flame.

JOHN ZINK CO.

Oklahoma Natural Gas Bldg.
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TULSA, OKLAHOMA

Its Sweetwater, Texas, refinery of 5000 barrels capacity, was recently completed. Additional installation of cracking facilities and crude capacity at other Gulf plants is included in the company's general program of improvement.

VACUUM BUILDING PLANTS

Vacuum Oil Company has closed contracts with Foster-Wheeler Corporation for installation of modern refining equipment at Vacuum Oil Company refineries in Budapest, Hungary; Hamburg, Germany; Kolin, Czechoslovakia, and Czechowice, Poland. Contracts include design and construction of modern refineries at these locations.

SOUTH PENN OIL COMPANY ACQUIRES EMERY PLANT

Tide Water Oil Company has sold its interests in the refinery formerly owned and operated by Emery Manufacturing Company, Bradford, Pennsylvania, to the South Penn Oil Company. The Tide Water and South Penn companies purchased this plant and certain pipe line and producing properties during the summer of 1928. South Penn Oil Company is now sole owner of the plant but the company has not yet announced what disposition will be made of the complete plant.

COMPANY ORGANIZED AT BRADFORD

Tio-Penn Refining Company, recently organized at Bradford, Pennsylvania, will operate the refinery at Tiona, Pennsylvania, which was formerly owned by the North Penn Refining Company.

Officers of the new company are Stearns Marshall, president; C. H. Messerly, secretary and J. L. Yerdon treasurer. C. H. Law is vice president and Dr. J. H. Pumphrey is director. Offices of the company are at 66 Main Street, Bradford. F. M. Mack is superintendent of refinery operations and is now supervising extension repairs at the plant. The 500-barrel plant has been shut down.

DEL RIO PLANT ENLARGING

Del Rio Refining Company is installing equipment at its Del Rio, Texas refinery to enlarge capacity to 5000 barrels daily from its present rating of 3500 barrels. The company is also re-opening sales office in Chicago with P. H. Hertzog, sales manager in charge. The company supplies fuel oil to the Southern Pacific railroad. Crude from the Yates field is supplied the refinery by Illinois Pipe Line Company.

RESEARCH LABORATORY

Imperial Oil Company, Ltd., Sarnia, Ontario, is preparing plans for the construction of a three story building, 100 by 100 feet in size, which will house its research laboratory. Foundations are to be started immediately under supervision of C. Leaver, manager.

Have you considered the application of Vapor Phase Refining in your plant? The chances are that you too will find it possible to

Increase your gasoline yields,

Improve your gasoline quality, and

Cut your refining costs.

We will be glad to go over your own conditions with you and show you how.

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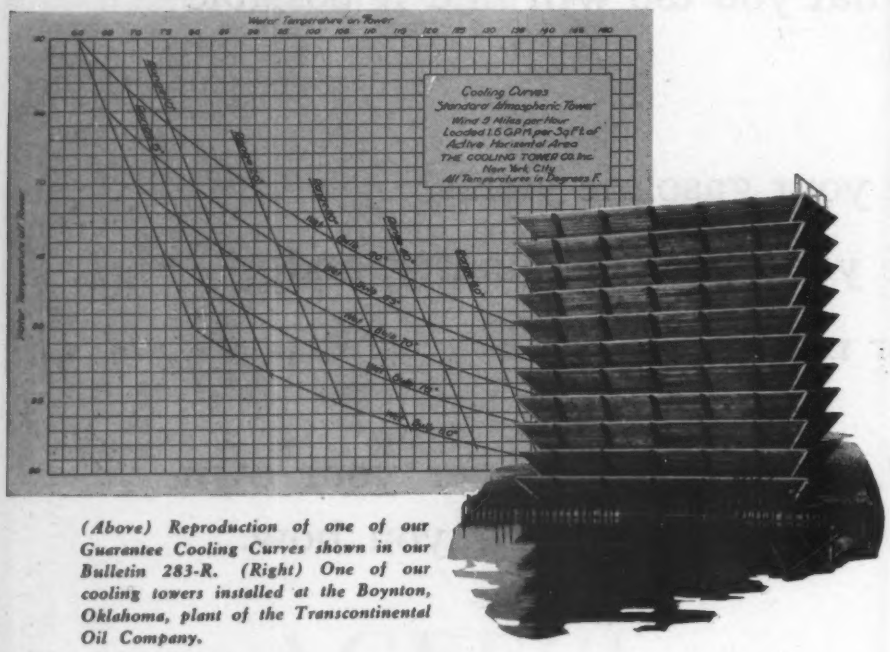
What Is This Knowledge Worth to You As a Buyer?

TO KNOW definitely, in advance, what cooling results you are going to get under any given atmospheric conditions. To know that these results are guaranteed by a company with 20 years of experience in the cooling tower field. To know that the cooling tower you buy is a carefully designed piece of engineering equipment built especially for your plant.

All these factors, and many others, are worth considering. To base your decision on price alone may prove expensive. The cooling tower which costs you more in the beginning may cost the least in the long run. From your experience you know this to be true with other equipment.

Bulletin 283-R should be in your files. A request will bring as many copies as you want by return mail.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Wind 9 Miles per Hour
Loaded 1.5 G.P.M. per Sq.Ft. of
Active Horizontal Area
THE COOLING TOWER Co. Inc.
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All Temperatures in Degrees F.

(Above) Reproduction of one of our Guarantee Cooling Curves shown in our Bulletin 283-R. (Right) One of our cooling towers installed at the Boynton, Oklahoma, plant of the Transcontinental Oil Company.

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Main Offices, 920 Market Street, St. Louis, Mo.

YATES PLANT STARTS

Humble Oil & Refining Company, Houston, began operating its natural gasoline plant in the Yates field, West Texas, December 12, thereby giving this major oil and gas producing area its first plant. Construction work was started early in July, 1929, on a site leased from I. G. Yates in Section 34, Block 194, GC&SF Ry. Survey, Pecos County, after long time gas contracts had been made with the principal operators in the field. The plant is equipped with the absorption process, and special provisions have been made to take care of gas containing a high sulphur content with a gasoline yield ranging from one-half to two gallons per 1000 cubic feet.

The initial gasoline yield of the plant, with only about one-half of the equipment in operation, averaged 12,000 gallons daily, but equipment will be available to handle from 25 to 30 million cubic feet of gas daily. An abundance of gas is assured for the field over a long period, as rigid proration rules prevent gas waste, while the oil producing area offers many hundred proven locations to drill when needed. About 35 miles of gas gathering lines, ranging from 16 to four-inch in size, have been built by Humble Oil & Refining Company, and a 25-mile four-inch welded line extends from the plant to the company's crude refinery at McCamey, where the natural gasoline will be used for blending.

W. P. R. TO MEET IN SHREVEPORT MARCH 10, 11 AND 12.

The annual meeting of the Western Petroleum Refiners Association will be held in Shreveport, Louisiana, March 10, 11 and 12, 1930. The Washington-Youree hotels will be the place for all sessions.

The program for the meeting is now being prepared and will be announced well in advance of the dates.

Riverton, Wyoming.—The old Midland Oil & Refining Company plant at Riverton, Wyoming, may be taken over, it is said, reconditioned, and placed on production of black oil if the plans now being formulated by L. M. Hines, president of Midland Oil & Refining Company and Wallace Leavitt of Denver, formerly with the Midwest Refining Company, materalize. This plant has a capacity for about 500 barrels and has been idle for many years.

Laurel, Montana.—The Laurel Oil & Refining Company has started construction work on a $1,000,000 refinery at Laurel, Montana. Brick work and steel structure are starting. This new refinery will operate on crude from the Oregon Basin field, northern Wyoming.

Standard Oil Company of New York, 26 Broadway, New York, has awarded contract for the construction of a laboratory at Brookyln to C. Curtis Woodruff, 213 10th Street, Long Island City Construction is to start at once.

SOLVAY PRODUCTS

58% SODA ASH

CAUSTIC SODA

Solid—Flake—Ground—Liquid

Leading refiners depend on these products for the quality and uniformity which industry inevitably associates with the name Solvay. First in pioneering the development of American sources of alkali, The Solvay Process Company is recognized as the outstanding leader of its field—first in size and first in facilities for rendering efficient service.

Strategically located distributing points ensure prompt delivery of Solvay products with minimum transportation charges.

Write today for prices and full information

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"SOLVAY" Trade Mark Reg. U. S. Pat. Off

Treating— Washing— Blending—

Inlet End

Duriron acid-proof Mixing Nozzles are recommended for:

Treating gasoline or light oil.

Treating crude oil for settling out water, basic sediment, etc.

Treating crude charge stock for lessening coke forming.

Treating bright stock.

Blending for initial boiling point and end point.

Treating casing head, (lime process).

Blending fuel oil and sludge.

DURIRON Mixing Nozzles are successfully used for the treating of light oils and lube stock, for blending and making up emulsions. They afford a better mixture with about one-third of the pressure drop required with orifice plates.

Maintenance expense is eliminated, as Duriron is chemically inactive to the corrosives used in the refinery; and it is so hard that its surfaces are not scored by high velocities. These nozzles are inexpensive in first cost.

Duriron Mixing Nozzles are easily and quickly adapted to any treating process. Made in 4-inch, 6-inch, 8-inch, 10-inch and 12-inch sizes.

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NATURAL GASOLINE PLANT DESIGN AND OPERATION

ANALYTICAL AND RESEARCH LABORATORIES

FRACTIONAL DISTILLATION ANALYSIS

LONE STAR GAS COMPANY INCREASE CAPACITY

Lone Star Gas Company through the addition of two plants has increased natural gasoline production so that it is now above 100,000 gallons daily. Lone Star Gas Company recently started operating a 10,000-gallon plant in Eastland County, and a 2000-gallon installation at Comanche County, Texas. The Gorden plant in Palo Pinto was increased from 25,000 to 35,000 gallons daily. The company now has a total of ten gasoline plants.

Early in December the Henderson Company completed installation of its new natural gasoline plant, absorption type, in the Texas Panhandle. It is rated at 12,000 gallons capacity. The new plant is located at Sanford, Texas, about 35 miles northwest of Amarillo.

GENERAL ENLARGING PLANTS

General Petroleum Corporation (Standard Oil Company of New York) of Los Angeles, California, has enlarged its natural gasoline plant in the Santa Fe Springs field, increasing the capacity of 185,000 gallons of gasoline daily. The company has found it necessary to add to the capacity of other plants as well, because of the ever increasing supply of gas brought about by the development of several new deep sands in the Santa Fe Springs fields. Five General Petroleum Corporation plants now have a combined capacity of 327,000 gallons daily. The company's Tonner Canyon plant in the Brea section of Orange County is shut down.

EMPIRE PLANT AT ARKANSAS CITY ENLARGED

Empire Oil & Refining Company is rebuilding its natural gasoline plant located near Arkansas City, Kansas, replacing practically all of the older equipment and increasing capacity to 10,000 gallons daily.

This plant was erected during the world war and was one of the first oil absorption plants to be erected in the Mid-Continent fields. Extension of the natural gas pipe line system into the Lovell-Marshal area renewed the volume of gas available for treatment at this old plant. The new installation will handle up to 40,000,000 feet of gas daily under peak load conditions in cold weather. The plant is located on the main highway about one mile north of Arkansas City enroute to Winfield, Kansas.

RIO GRANDE OIL COMPANY NOT TO MERGE

Officials of the Rio Grande Oil Company, Los Angeles, have issued a statement to the effect that the Rio Grande Oil Company is not figuring in a merger with the Richfield Oil Company of California, which proposed merger was mentioned in Wall Street dispatches last month.

NEW EQUIPMENT, CATALOGS, BULLETINS, BOOKS

New Auxiliary Control

FISHER GOVERNOR COMPANY

Several years of laboratory testing and preliminary field tests have been made prior to the formal announcement of the Fisher series 2200 specialties.

This control is auxiliary operated and is actuated by air, gas, water, or oil under pressure. It provides close regulation for those services where pressure must be maintained within very narrow limits. In gasoline plants and oil refineries there are many conditions requiring such a specialty. It may be used for relieving hot tar or hot oil at practically any pressure and temperature. The close regulation makes it especially adaptable for service as a relief valve on a residue gas line in a natural gasolint plant. The control can be applied for service as either a pressure reducing valve or pressure regulator or as a back pressure valve or relief valve.

The series 2200 control is designed to meet those conditions for which direct actuated specialties are not suitable. First of all, it is intended for any installation where the pressure must be controlled closely. As a pressure regulator, it controls the reduced pressure when this reduced pressure is nearly as great as the initial pressure. The series 2200 specialties are particularly adapted for installations handling oils, chemicals, and other fluids which are corrosive, under high pressure, at high temperatures, or which congeal when cooled. It is also used for installations where the load varies widely.

Its construction is for installation either indoors or out-of-doors. The control may be obtained in all pipe sizes and with practically every known kind and style of body construction and valve trimming, making it suitable for the variable conditions of pressure, temperature, and corrosion.

The series 2200 specialties are completely illustrated and described by the new Fisher bulletin, recently published by The Fisher Governor Company of Marshalltown, Iowa.

The Fisher Series 2200 Specialties are applicable to any piping installation. Shown here as a vertical installation in a horizontal pipe line

Welding Bulletin

The Linde Air Products Company, 30 East 42nd Street, New York City, has recently published "Fabrication of Welded Piping Designs," which is intended for the use of the executive, welder foreman and welder, to enable them to apply successfully the fundamental designs described in the former booklet "Design Standards for Oxwelded Steel and Wrought Iron Piping." The latter booklet was published several weeks ago, intended for the use of engineers and architects in designing oxwelded steel or wrought iron piping systems in accordance with recognized practice.

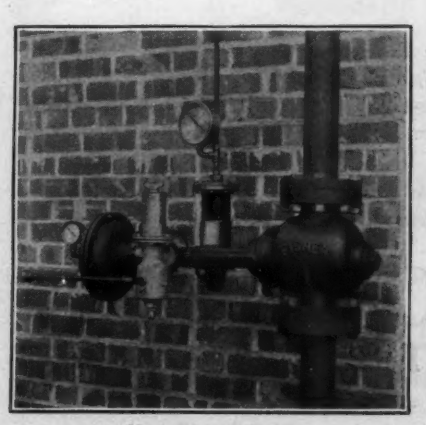
A supply of both of these booklets for district sales offices can be obtained from the technical publicity department of the company.

Staytite Expanding

The Staytite Company, 3608 Polk Avenue, Houston, has recently enlarged its general office building with the addition of a display room to house every product in the Staytite line.

A model tank with pipe line hook-up is being erected in this show room, and will be fitted with Staytite oil conservation and tank equipment, as the gas tight gauge hatch, swing lines, vent units, conservation vents, flame arrestors, tank nozzles, swing joints, cable sheave brackets, tank winches, roof manhole covers, and thief hatches.

The wall enclosure of this display room has been made approximately 50 per cent window space to provide almost as much light as is available in outside space.



The Fisher Series 2200 Regulator installed in a horizontal position in a vertical pipe line

Valve Catalog

A new catalog has been issued by Merco Nordstrom Valve Company featuring Nordstrom valves in various sizes with pressures ranging from normal to 1500 pounds. A large number of mechanical detail drawings are shown, indicating the construction of the various types of valves. Interesting information is given on the various types of lubricants to be used in lubricated valves at different temperatures form 20 to 350° F. and specific information regarding the type of lubricant to use for different contents within the pipe line. A large number of new illustrations showing application and installation of Nordstrom valves are shown in the catalog. Various tables of interest to the engineer are also included. Copies of the enlarged edition may be obtained from any of the offices of the company or by communicating with the head office, 343 Sansome Street, San Francisco.

Chapman at Houston

The Chapman Valve Manufacturing Company, Indian Orchard, Massachusetts, now has its Houston, Texas, warehouse at 2610 Bell Avenue, in full operation. This warehouse is stocked with gate valves in all sizes and types for oil, gas, air, steam and chemical lines at all pressures and temperatures. G. L. Griffin, branch manager at Houston, announces the addition of A. B. Harrison and H. B. Keir. The Houston sales offices are located at 1406 Esperson Building.

Gauge Catalog

The Bristol Company, Waterbury, Connecticut, has issued Catalog No. 1009 covering the company's recording pressure and vacuum gauges. It is a loose leaf catalog and furnished to supplement former information on the company's products. Sixty pages are devoted to index of materials carried and to charts on sizes and pressures. Thirty pages are devoted to illustrated descriptions on these gauges.

The company will furnish a copy of this catalog upon request.

Cooling Tower Bulletin

Edwin Burhorn Company, Bayonne, New Jersey, has issued a pocket-size eight-page pamphlet entitled "Streams of Gold," which briefly describes the operation of Burhorn cooling towers, and which gives examples of the economies effected through their use. Copies will be sent interested persons upon request.

The CF Duplex Sensitive Vacuum Regulator

We have especially designed this Regulator to serve where it is desirable to maintain atmospheric pressure on a system discharging gases to a line, under light pressure. It acts as a safeguard when used in the vapor lines connected to storage tanks, for the recovery of gases, the purpose being to prevent the pulling of a vacuum.

Every gas man who has not yet considered the working principles of this efficient Regulator is urged to write for a copy of our catalogue. All technical information is listed along with prices, etc.

The Chaplin-Fulton Mfg. Co.

Organized 1884—Oldest Builders of Gas Regulators in the Country. Built in all Sizes From 1 inch to 24 inches; For All Service. 1 oz. up to 2,000 lbs. Pressure to Square Inch.

28-40 Penn Avenue Pittsburgh, Pa.

Representatives:

WESTCOTT & GREIS, Inc.
Sales and Service
Dallas Los Angeles Tulsa

JNO. W. CRAWFORD
Sales Engineer
1855 Industrial Street, Los Angeles

Or Any Jobber

Resolve *NOW* to Make 1930 a SAFE Year!

Safety equipment literally saves *millions* in the oil industry each year.

There is nothing like PROTECTION, against the daily menace of fire and fumes.

A small investment in PULMOSAN Safety Equipment yields *big* dividends in time of an emergency.

Pulmosan-Lux Oil Fire Extinguishers
Pulmosan-Amco Non-Sparking Tools
Pulmosan Asbestos Fire-Fighting Outfits
Pulmosan Chemical Cartridge Respirators

Let us send full details on equipment listed above, and other suitable devices. Write for data on *Refinery Safety Equipment.*

PULMOSAN
SAFETY EQUIPMENT CORPORATION
"If It's for Safety . . . We Have It."
182 JOHNSON STREET BROOKLYN, N. Y.

Flour Changes Name and Adds to Facilities

The Fluor Corporation, Ltd., announces large additions to the manufacturing and office facilities simultaneously with the announcement of change in name from Flour Construction Company.

No change in management or executive personnel of the company has been made, according to P. E. Fluor, general manager.

On a site in Anaheim, California, recently purchased by the company, complete offices, small parts store room, garages, machinery, storage warehouses and other buildings, covering approximately two acres, have been erected. This division will hereafter handle all labor distribution for all jobs under construction, and serve as a storage depot for all construction machinery and supplies, as well as a base for the Fluor fleet of trucks. Approximately 200 men are regularly employed in this division.

The original cooling tower manufacturing plant, directly behind the main office building, will remain in its present location, providing direct contact with the personnel of the headquarters division. This plant employs approximately 75 men continuously.

The Fluor Corporation, Ltd., recently completed one of the largest single cooling towers in the world for The Texas Company at the Watson, Californi refinery. The dimensions of this tower are, 18 feet wide by 47 feet high by 840 feet long.

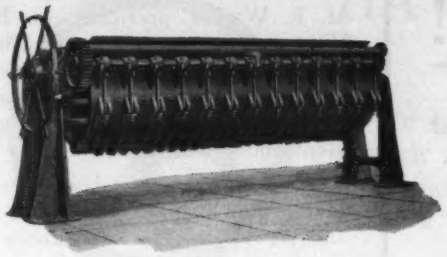
Another installation of interest in the construction line now under way is a seven unit high-pressure compressor station for the Barnsdall Oil Company of California in the Elwood, California field. The company also is building a four unit high-pressure compressor station for the Superior Oil Company at Santa Fe Springs.

William S. Waldrip, chief engineer for Neilan, Schumacher & Company, who has been in the east for the past several months, is returning to the factory in Los Angeles after being relieved by Werey. The New York office is located at 30 Church Street.

Shippers Car Line Corporation, 30 Church Street, New York, announces the opening of a western office in the Wright Building, Tulsa, to facilitate co-operation with Mid-Continent customers in negotiating and handling tank car leases.

Burrell-Mase Engineering Company, Pittsburgh, is rebuilding the absorption natural gasoline plant of the Equitable Gas Company, Pittsburgh. The gasoline plant operated by the Salem Gasoline Company at Salem, West Virginia, is also being remodeled and reconstructed by the same firm. At the Petrolia Pennsylvania refinery of W. H. Daugherty & Sons Refining Company, Burrell-Mase Engineering Company is erecting a new absorption type gasoline vapor recovery plant, which will be placed in operation at an early date.

Re-Filtering Lube Oil May Pay—



—why not investigate its possibilities?

Coke producers have a practice that may suggest a profitable step to you.

Notwithstanding the careful screening of coke during its production, a final screening is given at the loading point to eliminate fines or breeze . . . to eliminate "foreign matter" that hurts the marketability of the product.

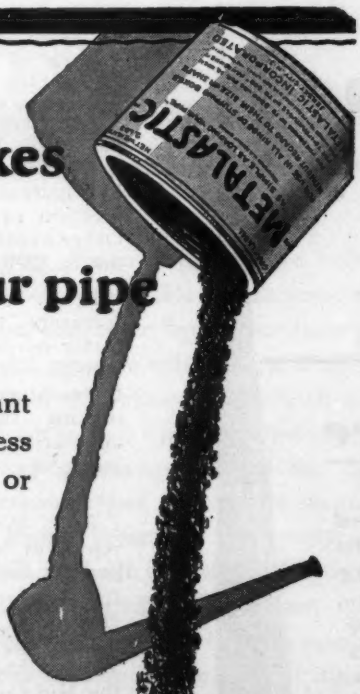
Like fines or breeze in coke, a little foreign matter in your lube oil may hurt its marketability. Why not refilter it?

Install the Sweetland Pressure Filter. It is already in use for such purposes.

OLIVER UNITED FILTERS, INC.

SAN FRANCISCO, Federal Reserve Bank Bldg.
NEW YORK 33 West 42nd St.
CHICAGO, 565 Washington Blvd.
LONDON, W.C.1, 150 Southampton Row.
PARIS, 63 Ave. des Champs Elysees
T. L. Genter, *Concessionaire*

Packing Stuffing Boxes as easy as loading your pipe



Serves in any plant equipment, regardless of service, pressure or temperature.

METALASTIC INCORPORATED
Jersey City, N. J.

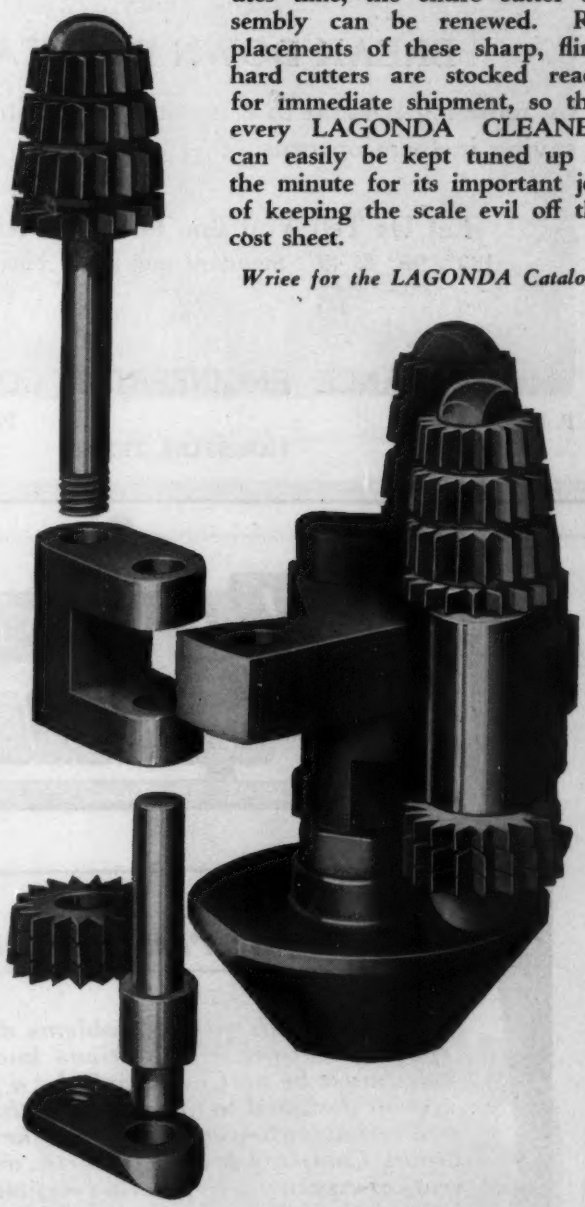
METALASTIC
For *All* Stuffing Box Requirements!

One bolt

assembles each cutter unit in the LAGONDA CLEANER

With a wrench, and a few minutes time, the entire cutter assembly can be renewed. Replacements of these sharp, flint-hard cutters are stocked ready for immediate shipment, so that every LAGONDA CLEANER can easily be kept tuned up to the minute for its important job of keeping the scale evil off the cost sheet.

Wriee for the LAGONDA Catalog



The Lagonda Mfg. Co.
SPRINGFIELD, OHIO
FUEL SAVING SPECIALISTS
NEW YORK, CHICAGO, PHILADELPHIA, BOSTON, PITTSBURGH, CLEVELAND, CINCINNATI, DETROIT, SYRACUSE, BALTIMORE, ATLANTA, ST LOUIS, KANSAS CITY, DENVER, DALLAS, SAN FRANCISCO, MONTREAL, LONDON.

Besides Tube Cleaners for Boilers, Condensers, and all sorts of tubes, Lagonda makes a very effective Cap and Header Reseating Machine, a Cleaner Feeding Device for curved tube boilers, a Boiler Tube Cutter of merit. Ask for details.

X-1458

Breaking Down Resistance!

Managers, Superintendents, Engineers and Foremen spend practically all their lives doing this very thing.

We Offer—

TUBE-TURNS, the stock fittings for welded piping, with their circular cross section and uniform wall thickness to help you to

BREAK DOWN RESISTANCE

by reducing friction to a minimum, cutting out leaks and saving installation time.

Let Us Tell You the TUBE-TURN Story.
180°, 90° & 45°, Standard and Extra Heavy, in Stock

by

MAINTENANCE ENGINEERING CORPORATION
P. O. Box 1402 Pres. 2274 — L.D. 409
HOUSTON, TEXAS

Power Piping
FOR EVERY OIL FIELD NEED

Engineering Service

In the oil field, special problems demand special treatment—conditions known to exist must be met exactingly by a piping system designed to fit and serve the purpose—that is when an institution like Power Piping Company proves its worth, with its years of experience in meeting oil field conditions. Complete piping systems designed and fabricated—bubble towers, heat exchangers, manifolds, headers, or welded work, too!

POWER PIPING CO., PITTSBURGH, PA.

O-1

NATURAL GASOLINE SUPPLY MEN ELECT

At a meeting held here in December M. F. Waters, president of Hanlon-Waters, Inc., was elected president of the Natural Gasoline Supply Men's Association composed of manufacturers and distributors of natural gasoline plant equipment.

A. J. Kerr of Pittsburgh Equitable Meter and Manufacturing Company and W. A. Schlueter of Refinery Supply Company, both of Tulsa, were elected vice presidents of the association and M. H. Kotzebue of Tulsa Boiler and Machinery Company was elected treasurer, with Ray E. Miller of Tulsa as secretary.

The above officers and the following are directors of the Natural Gasoline Supply Men's Association: R. E. Howe of Atlas Supply Company, Tulsa; J. B. McMahon of Foxboro Company, Tulsa, and E. R. Lederer of Fort Worth, vice president of Texas Pacific Coal and Oil Company who also is president of the Natural Gasoline Association of America; J. H. Satterwhite, general manager of Westcott & Greis, Tulsa; and William G. Cummings of Clark Brothers, Tulsa.

Employes of the Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, held a minstrel show and dance in the Elks Club ballroom December 13 to celebrate the completion of the company's project in doubling its plant, and also to celebrate the growth of the company's force from 750 to 1150.

The expansion program brings the company's plant now to cover approximately four acres, and represents the five increases in floor space since the erection of the original plant in 1903. Other expansion programs were carried out in 1906, 1918, 1925 and 1927.

Leeds & Northrup Company manufacturers products such as potentiometer pyrometers for controlling, indicating or recording industrial process temperatures, Hump and Home heat treating furnaces, combustion control apparatus and precision scientific instruments.

R. B. Werey has been appointed to represent Neilan, Schumacher & Company, manufacturers of automatic control and regulating equipment, in the New York territory. He was formerly design engineer with M. W. Kellogg, and has had considerable experience in the Mid-Continent and Argentine fields.

F. Van Acker, formerly chief engineer for Engineering, Research, and Equipment Company, at Dallas, Texas, is now chief engineer for Petroleum Engineering, Inc., with offices in the Philtower Building, Tulsa. Petroleum Engineering, Inc., was organized by Walter J. Podbielniak and Paul M. Raigorodsky, consulting engineers.

HAVING GASKET PROBLEMS?

LET US SOLVE THEM FOR YOU!

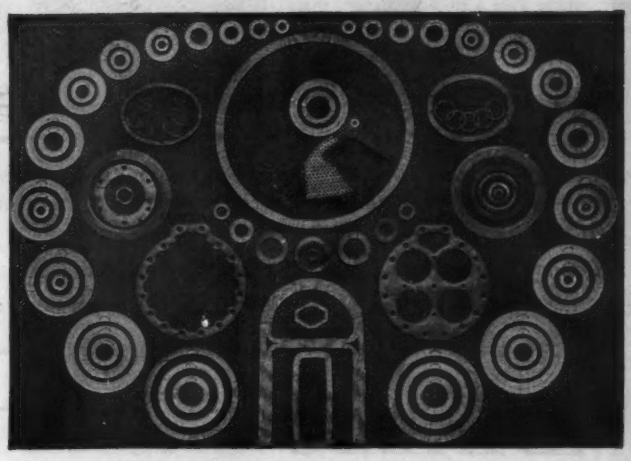
We make metal gaskets of any size or shape, plain or corrugated, with or without asbestos, also plain solid washers of copper, aluminum, monel metal or any material desired. Our Gasket Guide shows a very complete line of gaskets suitable for refinery work.

Copy sent upon request.

GOETZE

Gasket&Packing Co., Inc.

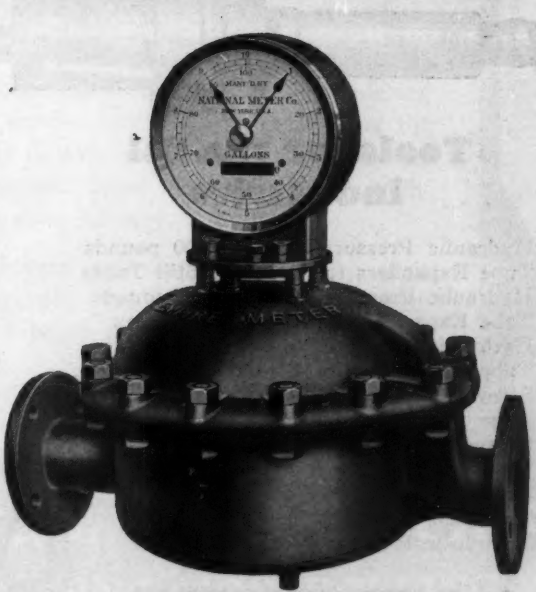
P. O. Box 175
NEW BRUNSWICK, N. J.



A Few Types of Goetze Gaskets

EMPIRE OIL METERS

The EMPIRE Oscillating Piston Meter is the best and most convenient instrument procurable for accurate measurement of oils, gasoline, and other liquid petroleum products. It has no equal for pressure still work, and all other measuring requirements of the refinery. EMPIRE meters are made in all sizes, from 5/8 to 6 inches, inclusive. Standard types will withstand a pressure of 150 lbs. to the square inch. High pressure types will handle up to 300 lbs. Meters for still higher pressures, and special types for special purposes will be built to order. The vertical dial as shown here, can be turned to face in any one of four directions. The hands can be set back to zero after any single run without disturbing the total of all the runs, which is recorded on a straight-reading register in the lower part of the dial face. Standard horizontal, straight-reading registers can be furnished if preferred.



EMPIRE meter accuracy has never been surpassed by any other meter, and what is more and better
THEY *STAY* ACCURATE

Send for fully illustrated descriptive EMPIRE circular No. 110-R

National Meter Co.
299 BROADWAY, N. Y.
Established 1870

For cracking process in oil refineries we furnish Aluminum Armored Asbestos filled Gaskets and Corrugated Armco Iron or Monel Metal Asbestos encased.

Copper rings 3/16" thick for 4 and 5" O. D. tubing.

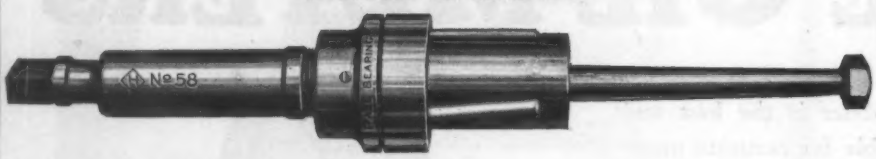
Washers or gaskets made of Aluminum, Copper and other Metals.

Write for Prices.

METALLO GASKET CO.

NEW BRUNSWICK, N. J.

Heavy Duty Expanders for Still Tubes



Tools for the Oil Industries

Hydraulic Pressure Pumps, 8000 pounds
Tube Expanders for Cracking Still Tubes
Hydraulic Pressure Pumps, 2000 pounds
Tube Expanders for Condenser Tubes
Hydraulic Pressure Pumps, 500 pounds
Tube Expanders for Steam Boilers
Screw Punches for Structural Shapes
Tube Expanders for Pipe Work
Screw Punches for Plate Work
Flaring Tools for Still Tubes
Beading Tools for Still Tubes
Hydraulic Jacks
Hydraulic Punches

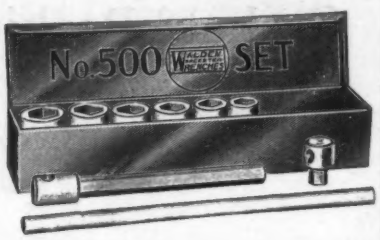
A. L. HENDERER'S SONS

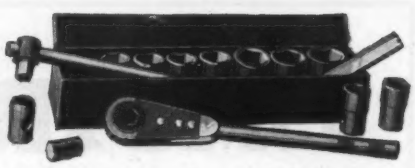
Wilmington, Del.
Established 1870
Expanders since 1884

Wrench Sets

The Stevens Walden-Worcester, Inc., of Worcester, Massachusetts, is now manufacturing and marketing to the oil industry a line of special shop tools, entering this field after many years of specializing in shop tools for the automotive industry.

The Walden heavy-duty wrench No. 510, illustrated here, represents a complete assortment of handles and sockets for turning large, awkwardly placed nuts and bolts. Contents of this set are 10 heavy-duty hex sockets ranging from one to two-inch, inclusive, a heavy-duty ratchet wrench, a plug connector, a heavy-duty extension bar, a cross bar handle and an offset adaptor. This set is housed in a steel box 20½ x 5½ x 3½ inches.





Set No. 500, shown here, is a compact set of heavy-duty wrenches containing a tee and offset handle with six sockets of nut sizes frequently encountered on heavy industrial equipment. The six sockets range in sizes from 1¼ to 1¾-inch.

No. 2285, a ratchet handle, is a hy-duty drop forged ratchet, ⅝-inch square opening, length 15 inches. It is made of chrome alloy steel.

No. OR916 is a ratchet handle with a ½-inch opening and a 1⅝-inch diameter head. The length is 10½ inches. This is a single action ratchet used with a detachable plug to fit any socket system. The plug, as in No. 2285 ratchet, is removable when worn, and another plug replaced.

Detailed information on this line of tools may be had by writing the company, requesting Catalog No. 116, which was recently issued.

The Vulrox Corporation has transferred the petroleum industries division formerly located in the Kennedy Building, Tulsa, to the home office, 2600 North Broadway, St. Louis. Robert Burnett, associate engineer, has resigned his position with this company.

A Carload of Hifire Brand Firebrick for Export

Demand for Hifire Brand brick is broad because users demand its exceptional quality. The materials and methods of manufacture give Hifire brick these properties:

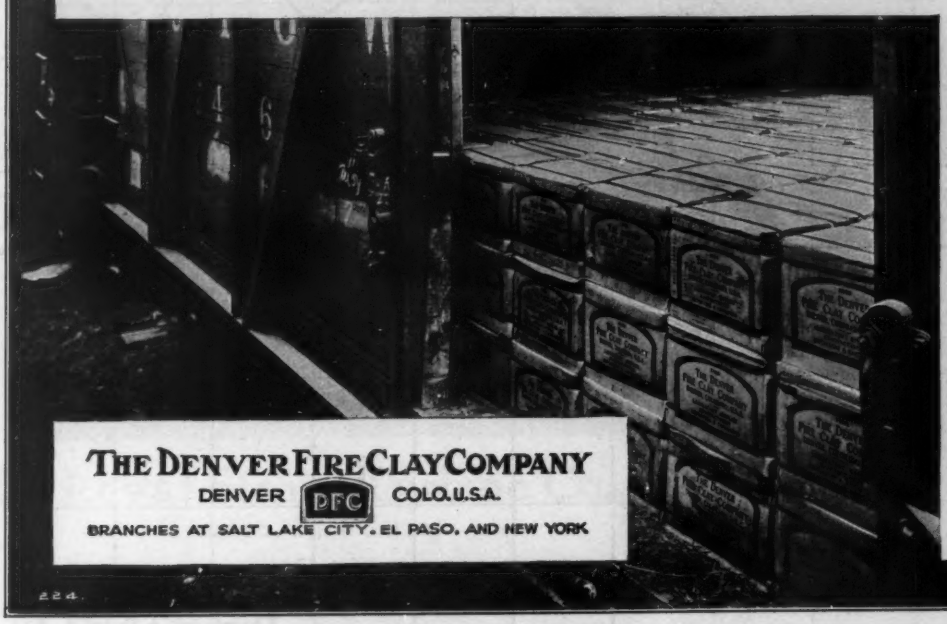
Trueness to shape and dimensions; uniform size; ease and economy in laying; high softening point; constancy of volume during service; and exceptional resistance to spalling.

Protect your fire brick investment with these high temperature cements:

HIFIRE BOND
Dry refractory cement for laying fire brick in the most severe furnace applications.
Economical. Refractory beyond Cone 32 (3218° F.)

PX-33 MOLDABLE FURNACE LINING
An unfired firebrick in stiff, mudlike form for repairing furnace walls, bridge walls, arches, jambs, etc., and for entire furnace linings. Far better furnace resistance and longer life than any fire clay brick in most applications.

LATITE
An air-setting cement combining this property with all the necessary requirements of a high grade refractory cement. Latite has set a new standard in furnace mortars and cements.



THE DENVER FIRE CLAY COMPANY
DENVER DFC COLO. U.S.A.
BRANCHES AT SALT LAKE CITY, EL PASO, AND NEW YORK

DFC refractories are sold by:

El Paso, Texas,
Neff-Stiles Company
Los Angeles,
H. F. Bakemeyer.
Ogden, Utah,
Ogden Press Brick & Tile Co.
Phoenix, Arizona,
V. L. Clark Bldg. Mat. Co.
Portland, Oregon,
Kline Specialty Co.
Provo, Utah,
Provo Brick & Tile Co.
Reno, Nevada,
Flanigan Warehouse Co.
San Francisco,
W. E. Mushet Co.
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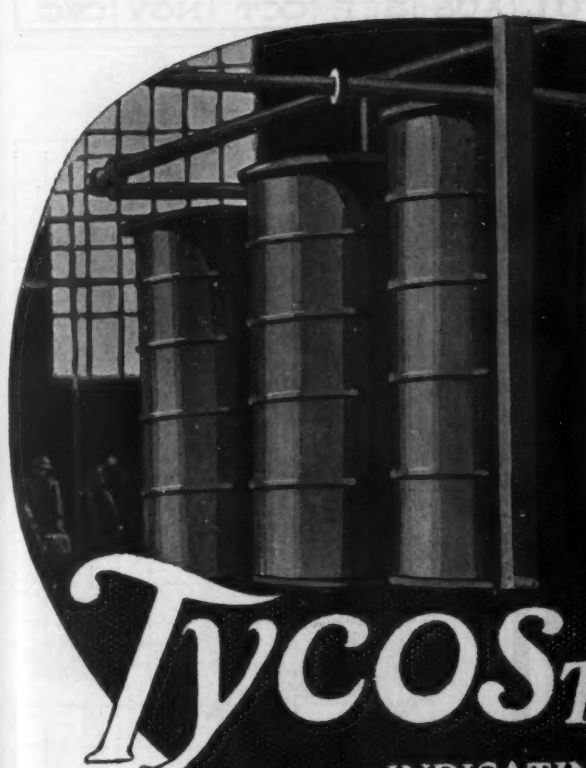
224.



There are hundreds of uses for Tycos Temperature Instruments in the Oil Industry for it is exceeded by few in the number and diversity of its temperature requirements.

Tycos Temperature Instruments are rendering excellent service to oil operators all over the world. It is with confidence, therefore, that we recommend these sturdy, reliable instruments for *your* refinery.

Our engineers will demonstrate why their uniform results and low upkeep make them worthy of being made the standard at your refinery.

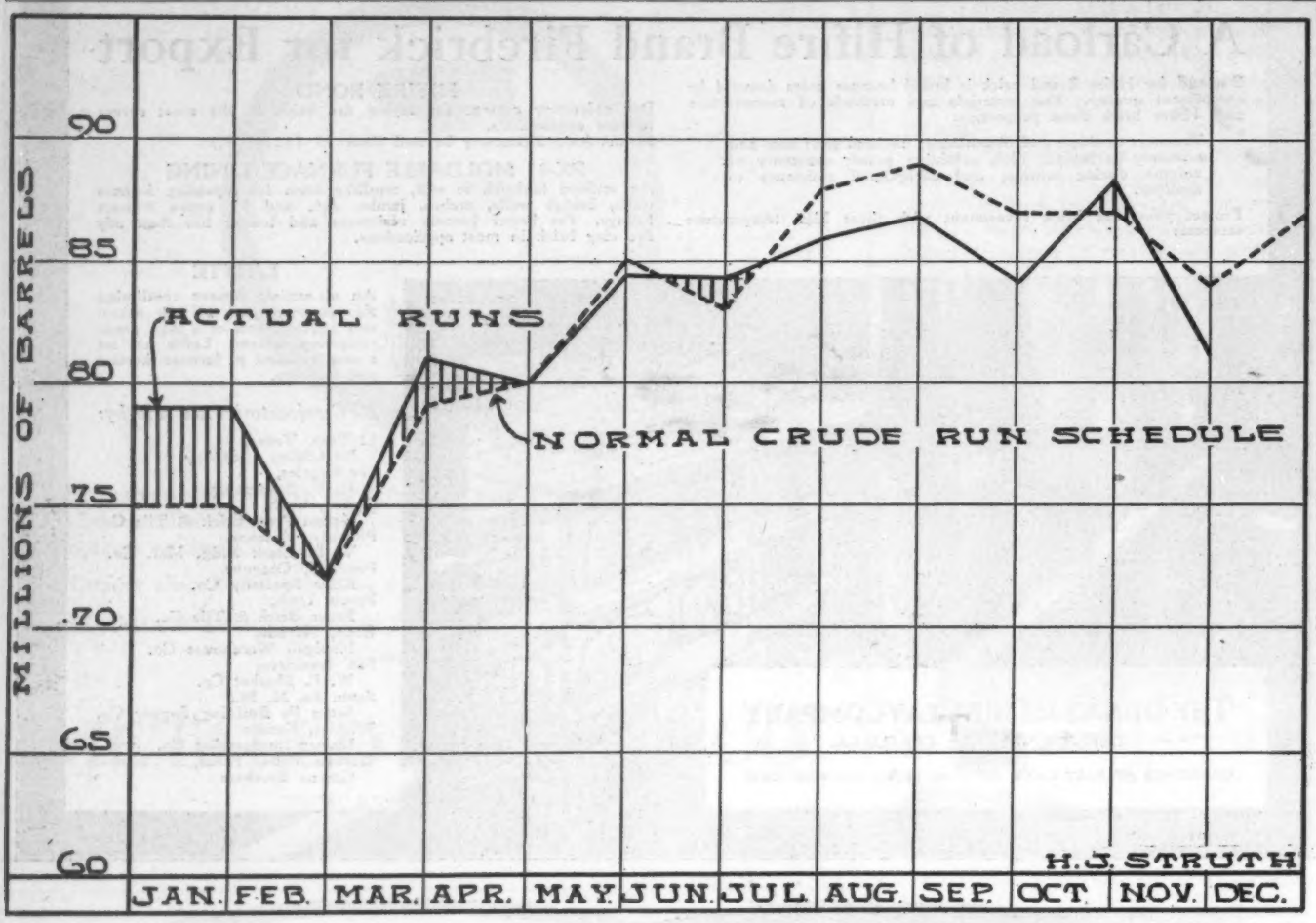
Tycos Temperature Instruments

INDICATING - RECORDING - CONTROLLING

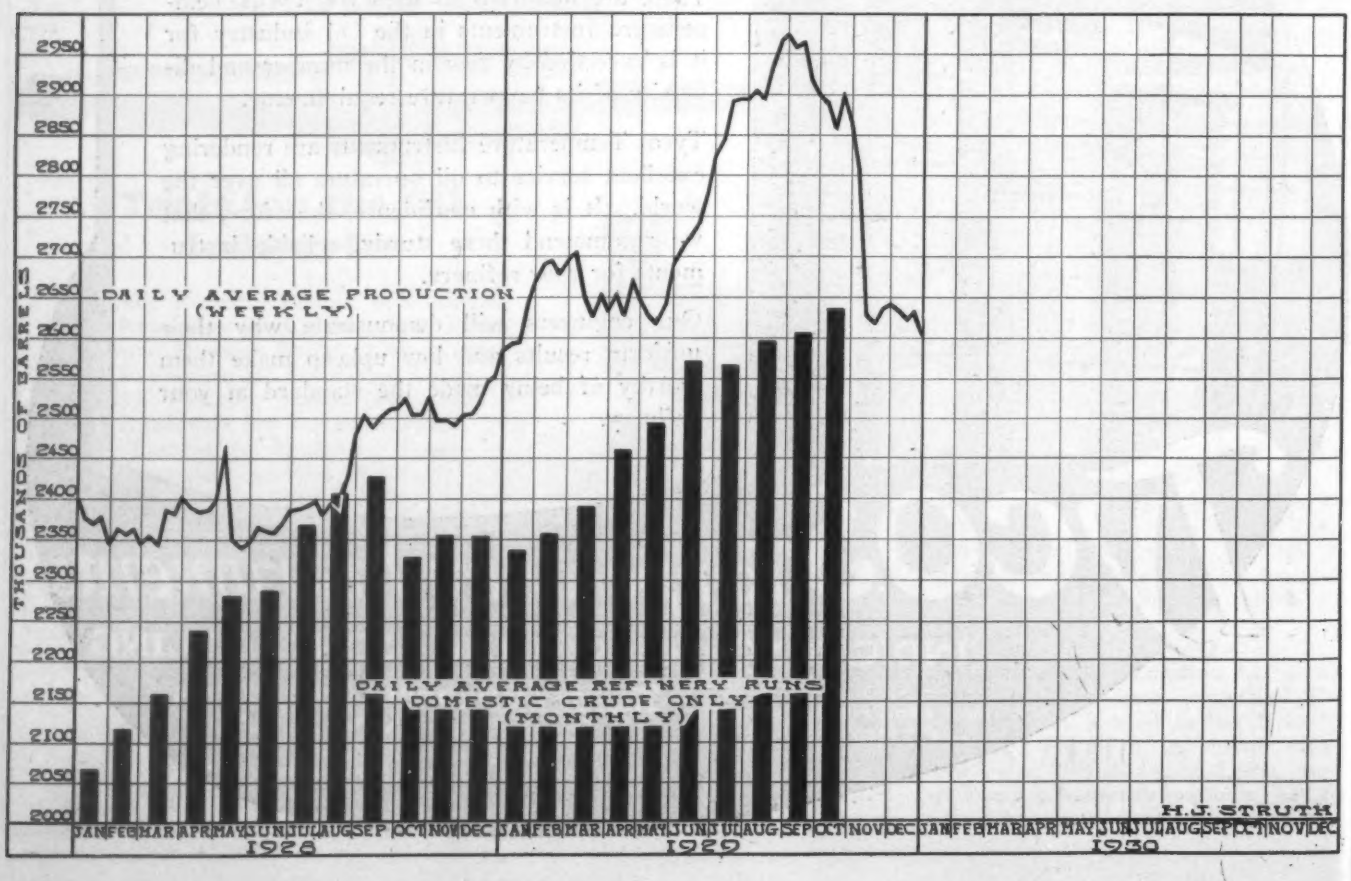
There's a Tycos or Taylor Instrument for Every Purpose

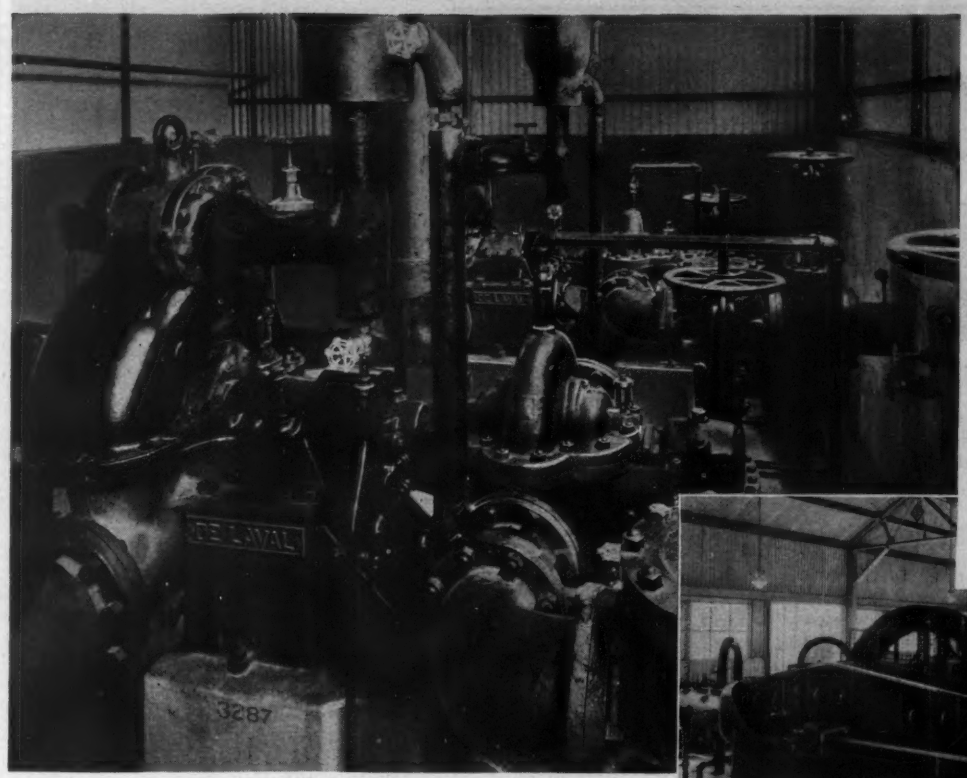
Taylor Instrument Companies
Rochester, N.Y. U.S.A.
Canadian Plant
Tycos Building, Toronto, Canada

REFINERY RUNS OF DOMESTIC AND FOREIGN CRUDE TO STILLS



DOMESTIC PRODUCTION AND REFINERY RUNS

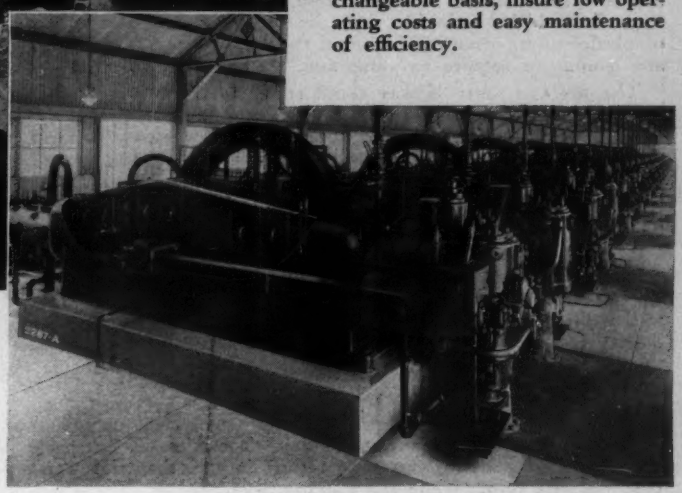




Continuous Night and Day Service

These De Laval Turbine driven centrifugal Pumps supply jacket cooling water to 52 reciprocating compressors, installed in a large compressor station. In another similar installation the De Laval circulating pumps have run continuously night and day for 23 months.

The design, materials and workmanship of De Laval pumps give the untmost in reliability. Removable labyrinth wearing rings, shaft protecting sleeves and casing protecting bushings, with construction on a limit gage interchangeable basis, insure low operating costs and easy maintenance of efficiency.



De Laval Steam Turbine Co.,
Trenton, New Jersey

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines, Flexible Couplings and Special Centrifugal Machinery.

3060

No Installation Expense

for this LIGHTNIN Mixer

There is no installation expense with this new portable mixer. It is easily attached to the side of any tank or container. Less power is used because of design having minimum of mixing mechanism in the tank.

Investigate this power saving, dependable and efficient principle of mixing all fluid products.

Write for Full Information

Mixing Equipment Co., Inc.

1040 GARSON AVE. ROCHESTER, N. Y.

There is a LIGHTNIN mixer for permanent installation too. This Side Angular Propeller Type Agitator is highly efficient and operates at a great saving in power. It is used extensively in the oil industry due to its adaption to any size of tank, open or closed. This mixer can be supplied in any size or speed.

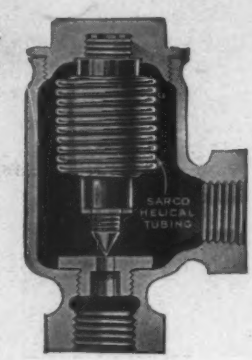
The boss says: "Since we installed Sarco Steam Traps we have used much less coal, resulting in a saving of hundreds of dollars. In addition, we saved about two-thirds of the money we expected to spend for traps."

The engineer says: "Sarco Traps made my job easier. I screwed them right into the pipe line without much work. If the boss had bought more of those old style bucket or float traps, I would have had to dig a lot of pits and build a bunch of platforms to install them. And the Sarco Traps never give any trouble or require any attention."

The fireman says: "I was about ready to throw up my job because I had to shovel so much coal that it was getting me. After they put in those Sarco Steam Traps it was easy to keep up steam with a whole lot less coal to shovel."

Sarco Steam Traps are self-adjusting for any steam pressure from 0 to 100 lbs. They have no floats, buckets or intricate parts to cause trouble.

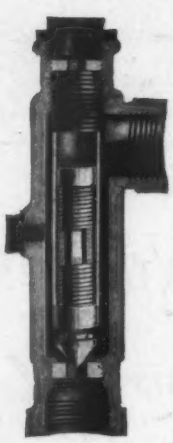
They are opened by condensation and closed by steam. Consequently they cannot freeze. Moreover, Sarco Steam Traps drain condensate as soon as it forms and return it to the hot well while still hot, so less coal is required to convert the condensation back into steam. Another important feature is that they cannot air bind.



Self-Adjusting Type No. 9 Sarco Steam Trap

FREE Trial

Let us send you a Sarco on 30 days' free trial. If not more than satisfied with it, you may return it and the trial won't cost you one cent. Write for Catalog S-95.



Adjustable Type No. 7 Sarco Steam Trap

SARCO CO. Inc.

183 Madison Ave. New York City

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SARCO STEAM TRAP

The Spiral Motion Is the Trick

That's why Hood's Chemico Spiral Packing Rings have been selected by so many engineers. The center hole prevents choking and clogging.

Made of acid-resisting shale—practically indestructible.

Used by all big producers because of the intensive movements.

Samples on request

B. MIFFLIN HOOD CO., DAISY, TENN.

FORT DEARBORN REFINING COMPANY ORGANIZED

Fort Dearborn Refining Company, recently organized, has taken over the plant of the Interocean Refining Company, at McCook, Illinois, manufacturers of high flash, zero test motor oils.

R. A. Fouts, formerly president of the Deepwater Oil Refineries, is president of the Fort Dearborn Refining Company. Sales of the new company are handled by Harry P. Dunn Company, 624 South Michigan Avenue, Chicago.

White Oak Refining Company has contracted its entire output from its refinery at Allen, Oklahoma, for the first three months of 1930. The products to be used for export purposes to France and England, according to Victor H. Smith, president. Smith sails for England on January 3. Total sales were for 3,850,000 gallons of gasoline.

White Oak Refining Company has just completed a deal for 1,250,000 barrels of crude oil. Of this amount 500,000 barrels was taken from the Mid-Continent Petroleum Corporation and the same amount from the Gypsy Oil Company, and 250,000 barrels from the Amerada Petroleum Corporation. The price was the prevailing market schedule. It is to be shipped to the company's Allen refinery, then to West Wego, Louisiana, suburb of New Orleans. The Allen refinery was recently remodeled and the capacity increased to 8000 barrels of oil daily.

Reorganization of Olney Oil & Refining Company, which operates a 2500 barrel daily capacity skimming plant at Olney, Texas, was completed about December 15, and plans have been formulated for the installation of equipment that will permit the handling of 3500 barrels crude daily. The crude supply is obtained from nearby fields on the Archer-Young County line.

The new Olney Oil & Refining Company has a capital stock of $40,000, chartered in Texas, with the following officers: O. T. Anderson, president; J. M. Bradshaw, vice president; R. G. Cocanower, secretary, and G. D. Anderson, Jr., treasurer. All refined products turned out by the plant will be marketed by the Union Oil Products Company, Wichita Falls, with J. M. Bradshaw in charge.

Operations at the Grand Prairie, Texas, plant of Tarrant Petroleum Company are being restricted to the blending of motor fuels from natural gasoline and naphthas obtained from refineries in Texas and Oklahoma. This company maintains headquarters in the First National Bank Building, Fort Worth, and acquired the plant last October from the Primtex Refining Company. The owners plan to recondition the plant, which is rated at 1500 barrels daily, to operate on crude when market conditions improve, and branch lines of The Texas Pipe Line Company and Magnolia Pipe Line Company are close by. However, the latter company has not made a deal to deliver crude as previously announced.